BLEACHED CTMP FROM DECAYED AND STAINED ASPEN LOGS

Prepared for

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SECTION I

ECONOMIC AND MANUFACTURING ANALYSIS

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Chapter 1

SUMMARY

General

Studies carried out over the past few years have indicated that aspen (Populus tremuloides) is a desirable species for bleached chemi-thermomechanical pulp (CTMP). This is in contrast to the use of aspen for chemical and pure mechanical pulp; there is a neutral reaction to the use of aspen in chemical pulp and a negative reaction to the use of aspen in a pure mechanical pulp.

Although it is now conceded that sound, clear aspen will produce a high quality bleached CTMP, the effect of stain and decay on the economic feasibility of a bleached CTMP mill has never been quantified. Virtually every naturally occurring harvestable aspen stand has stain and decay. It has generally been believed that this stain and decay would result in a severe cost penalty for any venture associated with aspen forest products.

Alberta contains about 45 per cent of the economically accessible aspen timber reserve in Canada. Thus, Alberta should obtain the largest economic advantage from the commercial exploitation of Canada's existing aspen stands.

The overall objective of this study is to determine the quantitative effect that stained and decayed aspen will have on the economic viability of a bleached CTMP mill. Only bleached grades (above 75 brightness) are considered viable for a market pulp mill. Unbleached pulps have steadily declined from 70 per cent of market pulp in 1950 to 15 per cent in 1980.

Wood Quality

Three deciduous stands containing primarily aspen were sampled to obtain logs representing four quality classes; clear, stain, intermediate decay and advanced decay. No attempt was made to obtain a representative cross section of an aspen stand. The forest structure is dynamic and sampling only represents the conditions at one point in time.

The decay content in the samples ranged from zero in the clear, sound aspen logs to 6.6 per cent by weight in the intermediate decayed logs to 33.8 per cent by weight in the advanced

decayed logs. The logs were chipped as obtained since this would be representative of a commercial operation; i.e. decayed wood was not separated from sound wood. Since decayed wood is less dense and weaker than sound wood, there is a greater tendency for decayed wood to be reduced to fines in the chipper. On a commercial basis, the chips from logs classified as advanced decay would give about four times as many fines as that from sound, clear aspen (9 per cent vs. 2.5 per cent). These chip fines would have no value in CTMP.

Yield Losses

In addition to the increased wood loss from decay during chipping and screening, there are other losses during chemical treatment prior to refining and during bleaching. Compared with sound, clear aspen, chips from the advanced decayed logs lost an additional 5.2 per cent during pulping and an additional 4.6 per cent during bleaching (combined pulping and bleaching yield 92.2 per cent for sound vs. 83 per cent for advanced). The wood requirements to produce a finished tonne of bleached CTMP from the various aspen logs are as follows:

Aspen Log Classification	Decay, % by Volume	Wood Requirements per ADMT Bleached CTMP	
Logs (75 yr. old stand)			
Sound, clear	0	1,021 kg.	
Stain	1	1,056 kg.	(+3.4%)
Intermediate decay	9-23	1,091 kg.	(+6.9%)
Advanced decay	37-50	1,240 kg.	(+21.4%)
Total 75 yr. old stand	2-3	1,035 kg.	(+1.4%)
Total 90 yr. old stand	6-7	1,057 kg.	(+3.5%)

The 75 year old stand (logs 72% clear, 19% stain, 9% decay) is representative of the O'Chiese block in the Brazeau region of Alberta and the 90 year old stand (logs 35% clear, 40% stain, 25% decay) is based on decay estimates of some work carried out in the Slave Lake area.

The above figures demonstrate that the cost associated with the additional wood required from a typical 75 to 90 year old aspen stand to produce bleached CTMP would not be significant.

Pulp Quality

For a bleached CTMP mill to successfully compete against bleached chemical pulp mills it must be capable of producing a number of high quality pulp grades for specific end uses. Sound, clear aspen in combination with varying percentages of softwood has proven to produce excellent printing and tissue pulp grades. The two major reasons for this are the desirable fibre morphology of aspen and the excellent response to bleaching.

The quality of the unbleached CTMP from sound, clear logs was only marginally better than that from the decayed and stained logs. However, after bleaching there is no significant difference in strength properties. CTMP from the stained and decayed logs also showed excellent bleaching response, although initial brightness was lower (7.5 to 11 points compared with sound, clear). After bleaching the difference was reduced to 2.5 to 5 points. The maximum practical brightness for CTMP from advanced and incipient decayed logs is considered to be 75; that from sound, clear logs, 80.

These results show that there would be no strength disadvantage for bleached CTMP produced from stained or decayed aspen. In addition, a 75 brightness (the minimum acceptable for bleached pulp grades) could be obtained even for CTMP produced from advanced decayed aspen logs.

Paper Quality

High quality, bleached CTMP for printing papers can be produced with aspen content up to 80 per cent, the remaining being softwood. Thus, it is extremely important to determine the effect of stain and decay on printability. Previous studies had shown that fine papers containing 20 per cent aspen bleached CTMP (which substituted for hardwood BKP) was equal or superior to the 100 per cent BKP control. In order to magnify the potential effect of decay, samples were prepared with 75 per cent bleached CTMP from advanced decayed logs—the results indicate marginally poorer surface strength and printability (3 to 8 per cent depending on property evaluated). However, for bleached CTMP from a 75 to 90 year old stand, even up to a 50 per cent bleached CTMP furnish level in printing papers, there would be no measurable difference in surface strength or printability.

High quality bleached CTMP for tissue can be produced from a 50 per cent aspen, 50 per cent softwood furnish. The pulp quality resulting from the stained and decayed aspen indicates that there should be no problem producing a tissue pulp grade from an aspen stand containing significant volumes of stained and decayed aspen.

Mill Design and Capital Cost

The optimum design for a two line bleached CTMP mill is a 50:50 aspen:softwood furnish. The effect on the design of this mill, introduced by stained and decayed aspen, is only significant for the woodroom and chip storage. For effective mill design and product flexibility it will be necessary to have a separate handling system for logs from stained and decayed aspen. The additional capital cost for this modification will be about $1.5 million, and the additional operating cost would be equivalent to two man years of labour.

There will be no effect on the design, capital, or labour required for pulping and bleaching. A minor effect of the decayed wood will show up in the effluent treatment due to the increased yield loss. However, even this will be insignificant for a typical 75 to 90 year old aspen stand.

Cost Factors

From the viewpoint of wood requirements, pulp quality, and mill design, the effect of stain and decay for a typical aspen stand as discussed above should not be any problem. However, there are definite operating and selling cost disadvantages that are a direct result of stain and decay which are significant.

The use of stained and/or decayed wood will increase the amount of wood, chemical requirement, effluent treatment and woodroom labour for bleached CTMP as follows:

Aspen Log Classification	Additional Cost $/ADMT bleached CTMP
Stain	25
Intermediate decay	33
Advanced decay	55
75 year old timber stand	10
90 year old timber stand	20

These additional costs are based on estimated wood and prevailing chemical and utility costs. Sound, clear aspen is used as the base case.

In addition to increased operating costs, there is a revenue penalty to pay for stain and decay. The lower brightness of bleached CTMP from stained and decayed aspen results in the following loss in revenue:

Aspen Log Classification	Average Revenue Loss $/ADMT bleached CTMP
Stain	13
Intermediate decay	30
Advanced decay	30
75 yr. old timber stand	5
90 yr. old timber stand	12

On this basis the total penalty for stain and decay ranges from $38 for stain to $85 for advanced decay per ADMT bleached CTMP. For a typical 75 and 90 year old stand, the penalty is $15 and $32/ADMT respectively.

Recommendations and Implications

It should be emphasized that the base line is sound, clear aspen which is easier to process than softwood. Power requirements are less and bleach response is better for sound, clear aspen than for softwood, even spruce. Thus, to put the cost penalties for stained and decayed aspen in commercial perspective, it is necessary to obtain representative softwood as well as aspen samples from a site specific area for evaluation, particularly bleaching response.

The cost for using stained and decayed aspen clearly illustrates the necessity of work required in forest management of aspen stands. A 75 year old stand, such as the O'Chiese block, becomes a 90 year old stand in 15 years; thus, the cost of using a specific aspen resource for bleached CTMP increases with time.

Prior to any decisions being made on the choice of using stained and decayed aspen or leaving it in the woods, detailed logging, extraction and transportation costs for aspen are required. This would require a site specific evaluation.

Conclusion

There are no significant operational or quality problems in the production of bleached CTMP introduced by using the entire wood from a 75 to 90 year old aspen stand. However, there are costs associated with the stained and decayed logs in these stands. These costs range from $15 to $30 per ADMT for pulp produced from wood representative of 75 to 90 year old aspen stands. However, in view of the advantages of sound, clear aspen for bleached CTMP compared with softwood, these additional costs should not seriously limit the commercial exploitation of a 75 to 90 year old aspen stand. The most important cost factor associated with wood in the production of bleached CTMP would not be the stain and decay in aspen stands up to 90 years old, but in the relative cost of softwood sawmill residuals compared with roundwood.

Chapter 2

INTRODUCTION

Alberta contains approximately 30 per cent of the commercially available forest resources in Canada. It is estimated that the potential incremental harvest from these reserves is about 15 million m^3 per year.

The forests of Alberta are primarily mixtures of softwoods, mainly pine and spruce, and hardwoods, mainly aspen (Populus tremuloides). The normal forest succession is first the hardwoods which grow rapidly and form an overstory, then the softwoods which grow up under the hardwoods. The hardwoods mature and die off, leaving a stand of mature softwoods. The softwoods then die, are burned or harvested and the cycle repeats itself.

In these mixed forests which have merchantable softwood sawlogs, the hardwoods will probably be in various stages of decay. These range from sound clear, sound stained, incipient decay to advanced decay. The degree of decay and its effect upon forest products depend upon the type of end product. Historically when the mixed stands were harvested, the softwoods were extracted and possibly some of the sound white aspen. The latter was used for lumber products.

The majority of the studies in the past carried out to determine the volume of merchantable hardwood have focussed on solid wood products. Logs containing stain and rot were judged unacceptable.

Mechanical and high yield pulping processes have developed to the point where a high quality bleached pulp can be produced at above a 90 per cent yield. The technological progression of these pulps is given below:

Process	Yield (% on wood)	Commercial Introduction
Stone Groundwood (SGW)	95	1860
Refiner Mechanical Pulp (RMP)	94	1961
Thermomechanical Pulp (TMP)	94	1968
Bleached CTMP	91-92	1978

Whereas aspen is not a desirable species for the SGW, RMP and TMP pulping processes, it is capable of producing a high quality bleached CTMP as a simple furnish, but more particularly in mixtures with specific softwoods (1,2,3).

Laboratory investigations with the exception of a few studies (4,5,6) have concentrated on the properties of sound clear aspen. In order to clearly define the extent and potential of the Alberta hardwood reserve, the effects of stain and various degrees of decay on cost and pulp and paper quality need to be established. Once the acceptable levels are established, more accurate timber reserves, recovery rates and extraction costs can be calculated. These figures are essential before a meaningful feasibility study for a pulp mill can be made.

Objectives

The overall objective of this study is to determine the quantitative effect that decayed and stained aspen will have on the economic viability of a bleached CTMP mill. The specific objectives are as follows:

1. To determine the effect of decayed aspen on wood costs resulting from additional chip fines and additional pulping yield loss.

2. To determine the effect of decayed aspen on the quality of aspen bleached CTMP, particularly regarding printing grades.

3. To determine the effect of decayed and stained aspen on bleaching costs.

4. To determine the effect of decayed aspen on the design and capital cost of a bleached CTMP mill.

5. To assess the potential of designing a quantitative test for measuring decay.

The study is divided into two sections. Section I (Chapters 1-8) analyzes the mill design, feasibility and economics of using stained and decayed aspen in bleached CTMP. The sampling procedures, laboratory pulping and bleaching studies, and printing evaluations are presented in Section II (Chapters 9-11).

Chapter 3

CHIP QUALITY

Log Sampling

Three deciduous stands containing primarily aspen were sampled to obtain logs representing the four quality classes: clear, stain, intermediate decay, and advanced decay. The sampling procedure carried out by W.R. Dempster and Associates is detailed in Section II, Chapter 8. Logs representing each class were sent to Econotech Services for chipping and pulping studies and to Alberta Research Council for decay analysis.

No attempt was made to obtain representative samples of the aspen stands. This was out of the terms of reference of the study and of no real value since the forest structure is dynamic and sampling only represents the conditions at one point in time. Instead, the properties of pulps representing a mature forest such as the O'Chiese block and an overmature forest such as the Slave Lake area were calculated from data for each wood type. The forest inventory data from the Pedology study (4) were used for the O'Chiese forest and the study by Thomas et al. for the Slave Lake - Whitecourt area.

The stained logs were all caused by or associated with Fomes igniarius (Linn). It is recognized that stains in aspen can be caused by bacteria as in the case of wet wood stain or other fungi. These types of stain will require further study to determine their effect on pulp brightness.

Chipping

The roundwood samples from Alberta were hand-barked and chipped whole by Econotech. Details are provided in Section II, Chapter 9. The chips were classified according to size and each fraction was analyzed to determine per cent decay on a weight basis. The reason for chipping whole logs, rather than separating the wood into the various components (e.g. clear, stain, decay as in the Pedology study (4)), is that the whole log is representative of a commercial operation. The effect of refining sound and decayed wood together is not necessarily the sum of refining each separately; sound, undecayed aspen fibres may protect weaker fibres containing decay from becoming severely damaged during mechanical treatment.

When logs are chipped, they produce chips varying in size from fine particles to large chunks. For mechanical pulping it is imperative that the chip size be uniform. Large chips and chip fines are unacceptable. Chips are usually classified by screen fraction with those larger than 1-1/8" and smaller than 3/16" being rejected by chip screens. The over-size chips are rechipped and rescreened. The -3/16" fraction is used for hog fuel.

Decayed wood is generally less dense and weaker than sound wood. As a consequence, it has a greater tendency to be reduced to fines in the chipper. The degree of breakdown also depends on the design and operation of the chipper. Further separation of decay may be achieved by techniques such as the Paprican process, which has been designed to separate sound wood chips from rot and bark (6). A drawback of the Paprican process (which has yet to be commercialized) is that water is used in the separation process which reduces the value of the decayed wood and bark for fuel.

Chip Properties

Pulp yield is a function of the losses that occur in pulping and bleaching and woodroom losses. Pulp quality is a function of wood quality and pulp mill design.

In stone groundwood and thermomechanical pulping (TMP), the presence of decay downgrades the pulp because of lower brightness, lower strength and excessive dirt or specks (4). The degree of problem depends on the amount of decay and kind of decay (brown or white rot), brown rot being more severe.

The aspen log samples representing the intermediate and advanced decay contained the wood rot fungus Fomes igniarius (Linn) Fr. This is a white rot which attacks mainly the heartwood. In initial stages of attack or incipient decay this fungus or associated fungi discolour the wood but does not significantly affect the strength of the fibres. As decay progresses the fungus degrades the fibres individually resulting in a general loss in mass and strength. In contrast to the grown rot fungi which attack all of the fibres uniformly, the white rot fungi attack a fibre, solubilize it by acid hydrolysis, then attack other fibres. In the samples used for the study the intermediate and advanced decayed wood had soft cores due to loss of wood. This is typical of Fomes igniarius. The strength of the remaining fibres in the center and the outer bank of sound wood should not be significantly affected.

The amount of decay in the samples was classified in the forest on a volumetric basis and in the laboratory by physical separation and gravimetric means. The chips from each log were also treated with sodium hydroxide to establish if a chemical analysis was practical for decay or stain classification. Samples of wood were also sent to Alberta Research Council for U.V. evaluation; however, these results were not available for this report. The evaluation of decay content is summarized in Table 1. Details are given in Section II, Chapter 9. The percentages of decay by volume and weight are as expected. Since the decayed wood is less dense than sound wood, a volumetric evaluation will always give a higher value than a weight basis. The caustic solubility test was too insensitive to be used for determining decay.

Table 1

Evaluation of Rot Content
(Bark Excluded)
Summary

Sample	% Volume (Dempster)	% Weight (Econotech)	% Caustic Solubility (Econotech) -7/8 +3/16 chip fraction
Clear Logs	0	0	22.4
Stained Logs	0	1	20.7
Intermediate Decayed Logs	9-23	7	21.5
Advanced Decayed Logs	37-50	34	23.5

A summary of the chip classification is given in Table 2. As expected, the fines content is higher for the samples containing decay. It is surprising that the percentage of fines from the logs classified as advanced decay is only 5 per cent since the wood contains 33 per cent decay. The percentage of decay for each chip fraction was determined and is given in Section II, Chapter 9. In spite of the fact that the -3/16 fraction of the advanced decay sample contains at least 90 per cent decay, the +3/16 fraction still contains 50 per cent decay. For the pulping study, based on WRA's recommendation, the -3/8,+3/16 fraction was excluded. This was later found to be unnecessary.

Table 2

Chip Classification Summary

Williams Classification	Aspen Log Type			
	Clear	Stained	Intermediate Decay	Advanced Decay
	- - - - composition by wt per cent - - - -			
+ 7/8 in.	35.4	26.5	33.1	21.5
-7/8 +3/16 in.	63.8	71.8	65.1	73.4
-3/16 in.	0.8	1.4	1.8	5.1

Wood Requirements

The wood requirements for a tonne of finished market pulp (i.e. air dried metric ton) are shown in Table 3. For comparison, the incremental wood requirements for each of the four wood types are presented. Based upon trees sampled in the O'Chiese Block and Slave Lake region and reported in the Pedology and Thomas studies, the actual wood mixes from 75 yr. old and 90 yr. old stands would be approximately:

Wood Type	Percentage of Stand[1]	
	75 yr. old	90 yr. old
Clear Logs	72	35[2]
Stained Logs	19	40[2]
Intermediate decayed Logs	6	17
Advanced decayed Logs	3	8

[1] Measured on a volume basis

[2] Estimates based on proportions in 75 yr. old aspen stand.

These figures for the 75 yr. old block compare favourably to an estimate of 25 - 30 per cent reject for solid wood products where no decay and little stain is accepted. The yields in pulping and bleaching are based upon the Econotech laboratory studies. A nominal 2 per cent loss in the mill is applied to all cases to cover spills and fines losses to effluent. The laboratory chipping produced a fines content of about 1 per cent. In practice this is nearer 2.5 per cent for sound wood. The woodroom losses have been adjusted upwards by 1.5 per cent for all cases to allow for this difference with the exception of the chips from the advanced decay logs. The fines content was first increased by 50 per cent before adjusting upwards by 1.5 per cent. These figures show that for normal 75 and 90 year old stands of aspen, the wood requirements are only marginally higher (1.5% and 3.5% respectively) than for a stand of 100 per cent sound aspen (Table 3). If only logs classified as advanced decay were used, the total wood requirement would increase by about 20 per cent above that for sound wood.

Table 3

Unit Material Balance - Fibre

Aspen

	Units	Log Classification				Log Mix as in	
		Clear	Stain	Intermediate Decay	Advanced Decay	75 yr. old stand	90 yr. old stand
Finished Pulp	Kg AD	1,000	1,000	1,000	1,000	1,000	1,000
Moisture Content	%	10	10	10	10	10	10
Weight of Fibre	Kg BD	900	900	900	900	900	900
Misc. Mill Losses	%	2	2	2	2	2	2
Pulp req. to Press	Kg BD	918	918	918	918	918	918
Bleaching Yield	%	97.5	94.8	94.7	92.9	96.7	95.6
Pulp to Bleach Plant	Kg BD	942	969	969	988	949	960
Pulping Yield	%	94.6	94.5	94.3	89.4	94.4	94.1
Wood to Pulp Mill	Kg BD	996	1,025	1,028	1,105	1,006	1,020
Woodroom Yield	%	97.5	97.1	95.8	90.9	97.3	96.5
Wood to Mill per ADMT pulp	Kg BD	1,021	1,056	1,091	1,240	1,035	1,057

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Chapter 4

EFFECT OF ASPEN DEFECT ON PULP QUALITY

General

In order for a market CTMP pulp mill to be successful it must produce a variety of high quality bleached pulp grades with uniform quality that are tailored to end use specifications. In order to achieve this the mill should be designed with a high degree of flexibility and control. The major end uses of the market bleached CTMP will be for printing and writing papers, tissue, paperboard and diaper. Previous studies have shown that sound aspen is ideally suited for use in printing and writing papers and, if the finer fibre fractions are removed, for tissue. Aspen bleached CTMP is less desirable for paperboard grades and undesirable for diaper. In combination with softwood in a properly designed mill, excellent pulps can be produced for most paper grades. This will be described in more detail in Chapter 5 on mill design.

It is now recognized that sound aspen is a desirable species for bleached CTMP. However, virtually all aspen stands have some timber that contains stain and/or decay. The specific effect of this defect on pulp quality is analyzed below.

Laboratory Pulping Studies

Chips from the four wood types were impregnated with a solution of sodium sulfite at pH 8 according to conditions outlined in Section II, Chapter 9. These chips were then refined to four freeness levels, one of which is satisfactory for printing/writing grades and one for tissue and board grades. The printing/writing pulp samples were bleached with hydrogen peroxide to maximum practical brightness levels. Strength and brightness results are summarized in Table 4 and detailed in Chapter 9. The unbleached tissue and board grades show a marginal decrease in strength properties with stain and decay.

Table 4

Laboratory CTMP Test Results
Summary

Property	Printing & Writing Grade Pulp - Bleached				Tissue and Board Grade Pulp - Unbleached			
	Sound	Stained	Int. Decay	Adv. Decay	Sound	Stained	Int. Decay	Adv. Decay
	- - - - - - log type - - - - - -				- - - - - - log type - - - - - -			
Freeness CSF, ml	151	154	155	180	300	300	300	300
Bulk, cc/g	1.7	1.6	1.7	1.7	2.4	2.4	2.5	2.5
Burst Index, kPa m^2/g	2.8	2.7	2.6	2.7	1.4	1.0	1.1	1.3
Tensile, km	5.7	5.5	5.5	5.2	3.5	2.7	2.9	3.3
Tear Index, mN m^2/g	6.5	6.6	6.1	5.9	5.0	3.8	3.8	4.4
Opacity, %	81.5	81.8	82.5	83.6	-	-	-	-
Brightness, %	80	77.3	74.2	74.6	-	-	-	-
Fibre Length Dist.								
Retained 48 Mesh, %	43.7			51.2	56.0	47.1	49.4	54
Pass 100 Mesh, %	32.0			25.9	22.4	25.5	29.5	22

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Since bleaching response is not a function of freeness only the samples for printing/writing grades were bleached. Bleaching increased strength properties of pulp produced from all classifications of aspen wood by 30 to 87 per cent depending on property and decreased freeness. The results from sound clear aspen are shown in Table 5. The tissue and board samples would also show a corresponding increase in strength upon bleaching. The results show that the bleached pulp is entirely different from a quality viewpoint compared with the unbleached pulp.

Table 5

Printing and Writing Pulp - Sound Wood

Property	Unbleached	Bleached	Change
Freeness CSF, ml	213	151	-62 ml
Bulk, cc/g	2.4	1.7	-29%
Burst Index, kPa m^2/g	1.5	2.8	+87%
Tensile, km	3.8	5.7	+50%
Tear Index, mN m^2/g	5.0	6.5	+30%
Opacity, %	94.7	81.5	-13 points*
Brightness, %	60.7	80	+19.3 points*

* Opacity change due to increased brightness and increased bonding.

The presence of 30 per cent decay in wood had only a marginal effect on the physical properties of the wood. Bulk and burst remained constant while tensile and tear decreased approximately 10 per cent. These strength levels are quite satisfactory for printing papers. This minor change in physical properties for bleached CTMP is expected from wood attacked by white rot fungus. There is more reflecting surface as shown by the higher opacity and a small reduction in intrinsic fibre strength.

The improved strength of the advanced decayed wood is also due to greater chemical consumption as shown by the bound sulfur in Chapter 9. The higher chemical consumption is probably due to the fungi increasing the surface area available for chemical reaction as well as increased dissolution of the wood (yield loss). The actual effect that this has on fibre bonding and thus paper strength is not known. For sound wood pulp strengths increase with increasing sulfonation.

The major effect of fungal attack is on pulp brightness. Brightness dropped from a high of 80 for clear wood to 74.6 for advanced decay. The minimum brightness for high quality pulp is 75 thus the intermediate and advanced decay woods are just marginal. The brightness of mixtures tends towards the brightness of the darkest component (not an arithmetic average). On this basis a 75-year old aspen stand would give a composite maximum practical brightness of 78 and a 90-year old aspen stand, 77 if the stained and decayed logs were not separated from the sound, clear logs.

Effect of Decay on Bleached CTMP for Printing/Writing Papers

Printing and writing papers cover a wide range of grades. The major divisions are "wood containing" (those papers with over 10 per cent mechanical pulp) and "wood free" (chemical pulp greater than 90 per cent). Mechanical pulps are already well accepted in high quality printing papers. As an example over 50 per cent of the fibre furnish for light weight coated (LWC) papers is mechanical pulp. Due to quality, bleached aspen CTMP has excellent potential in the "wood free" grades. Typical "wood free" grades are duplicating, carbonless, bond and business forms.

For printing papers, the printability of the sheet is the single most important characteristic. Two major printability criteria are legibility and visual impact. The legibility of the sheet can be determined by the uniform distribution of ink on the surface of the paper and by the show-through of ink from the opposite side of the paper interfering with the readability. Visual impact is influenced by the contrast of the printed image.

High quality printing and writing papers must be aesthetically pleasing, which generally requires bright, clean paper with a high degree of gloss. The surface of the sheet

must be smooth to give even printing and have a structure which controls the penetration of the ink into the sheet. Some of the major parameters for good printability are: optical (opacity, brightness), gloss, smoothness, show-through, strike-through, opacity, rub-off and set-off, and linting propensity. The importance of each of these parameters will vary depending on the type of paper being used and the printing process.

Previous studies (1,2) have indicated that sound aspen bleached CTMP meets all of these criteria. The question again is: Does decay have an adverse effect on printability? As noted above, the presence of high amounts of decay will reduce pulp brightness. However, the percentage of decayed logs being delivered to the mill is not likely to cause significant brightness problems. The unbleached pulp containing decay had noticeable amounts of dark specks. These disappeared when the pulps were bleached. This is shown in the handsheets in Chapter 9. All of the pulps had less than 0.1 per cent shive or fibre bundles. The limit for printing papers is .05 per cent. This level can easily be achieved by the standard screening and cleaning system.

The effects of decay on sheet formation, surface strength and printability were evaluated by MacMillan Bloedel Research (Chapter 10). Aspen CTMP from sound, clear aspen was previously evaluated by MacMillan Bloedel Research (1) for the production of high quality bond papers. Twenty per cent bleached aspen CTMP was mixed with 40 per cent hardwood BKP and 40 per cent softwood BKP. The aspen containing paper was found to be equal or superior to the 100 per cent BKP control (60% hardwood BKP: 40% softwood BKP) in most strength and printability properties. To magnify the effect of decay on these properties, the percentage of bleached CTMP was set at 75 per cent with the remainder semi-bleached kraft. Details of the printing study are given in Section II, Chapter 10.

Two pulps were evaluated, bleached CTMP from sound, clear wood and bleached CTMP from logs classified as advanced decay. The decayed wood resulted in slightly poorer formation which was reflected in all sheet and printing properties. Printability was 4 per cent, roughness and porosity 8 per cent and surface strength 3 per cent poorer for the decayed wood. These differences are considered insignificant in view of the high CTMP content (75% vs. a normal of 20%).

The laboratory studies indicate that the presence of advanced decay even for overmature aspen stands should not adversely affect printability properties, with the possible exception of brightness.

Effect of Decay on Pulp for Tissue

The most important properties of tissue products are water absorbency, softness, strength and aesthetic appearance. These properties are determined by the characteristics of the fibres in the furnish and the papermaking techniques.

The brightness and colour of the pulp is important from the consumer point of view. High grade tissue products must be both bright and white. A minimum of 75 brightness is necessary and 80 is desirable. Since cleanliness is equated both to brightness and to the presence of lint and dark specks in the tissue, the tissue must be free of bark particles and dirt.

Previous studies have shown that aspen bleached CTMP in conjunction with the long fibres from softwood bleached CTMP produces a high quality pulp ideally suited for tissue. In Sweden, Rockhammars Bruk are successfully marketing a pulp containing 50 per cent aspen and 50 per cent spruce bleached CTMP for tissue.

Aspen bleached CTMP that has had a mild chemical treatment contains too high a fines content for use on modern high speed tissue machines. There is evidence that the fines content can be reduced by higher chemical application and longer reaction times. There is however a reduction in bulk which will reduce absorbency. The application of more severe chemical treatment has not been addressed in this report.

The properties of unbleached tissue grade aspen CTMP are shown in Table 4. As previously discussed, these data refer to unbleached pulps; pulp strengths would be significantly higher upon bleaching. There is no major difference in strength or bulk between the sound and advanced decay pulp. The fines content shows some variation between samples, but this variation does not appear to correlate with decay.

From these data it is concluded that with the possible exception of brightness, stained and decayed aspen in combination with softwood present no problem for use in bleached CTMP tissue grades.

Effect of Decay on Pulp for Paperboard

The production of paperboard[1/] presents a number of challenges to the paper maker that are not presented in other papers. Some paperboard grades must have a surface which is smooth, can be readily coated and have brightness characteristics equivalent to those of printing papers. All paperboard must have sufficient strength and stiffness for packaging, yet have sufficient flexibility to be folded. Most high quality paperboard is composed of three to five layers of pulp. The outside layers or plies are normally produced from kraft pulp. The top layer, which is generally the printed layer, is produced from fully bleached kraft, whereas the bottom layer can contain either semi-bleached or unbleached kraft. The centre plies can be produced from waste fibre and/or mechanical pulp.

Aspen is not an ideal wood for paperboard because of its inherent short fibres. Softwoods are preferable because of superior bulk and strength/drainage characteristics. In a mixture with softwoods the longer fibre fraction from the aspen could be used for paperboard, (e.g. Rockhammars' paperboard bleached CTMP grade contains 20% aspen). This is described in Chapter 5. Based upon the laboratory studies there should be no more problem producing paperboard from advanced decay aspen than from the clear aspen.

Conclusions - Technical

CTMP of comparable quality can be produced from aspen which is clear, stained or decayed. All of the pulps are suitable for use in high quality printing/writing papers and, in combination with softwood, for tissue and board.

1/ In this case paperboard represents solid bleached board and folding boxboard. Corrugated board (from linerboard and corrugating medium) is not included.

Chapter 5

EFFECT OF ASPEN DECAY ON MILL DESIGN

General

Wood is converted from logs into baled bleached CTMP in six distinct process steps. They are:

- wood handling
- impregnation and refining
- screening and cleaning
- bleaching
- flash drying
- finishing

The quality of the final product is determined by the design and operation of each of the stages.

As discussed earlier, the market CTMP mill can only be successful if it produces uniformly high quality pulp specifically tailored for given end uses. As noted in Chapter 4, the major end uses require entirely different types of pulps. In general for high yield pulps, the fines fractions are excellent for printing grades whereas the long fibres are better for tissue and paperboard. Neither is ideally suited for the full range of requirements. The pulp mill can be designed to use both aspen and softwood and take advantage of the long fibres of both species for tissue and paperboard and intermediate and fines fraction for printing papers. This is accomplished by fibre fractionation.

The conceptual design of a two-line mill to produce high quality bleached CTMP from 50 per cent aspen and 50 per cent softwood is shown in Figure 1.

The mill is designed for 500 ADMT/d of bleached CTMP. This is the economy of scale for a two-line mill. Printing and writing pulp is produced from aspen on one line and the higher freeness tissue and paperboard pulp from softwood on the other. The design is described in detail in another study (1).

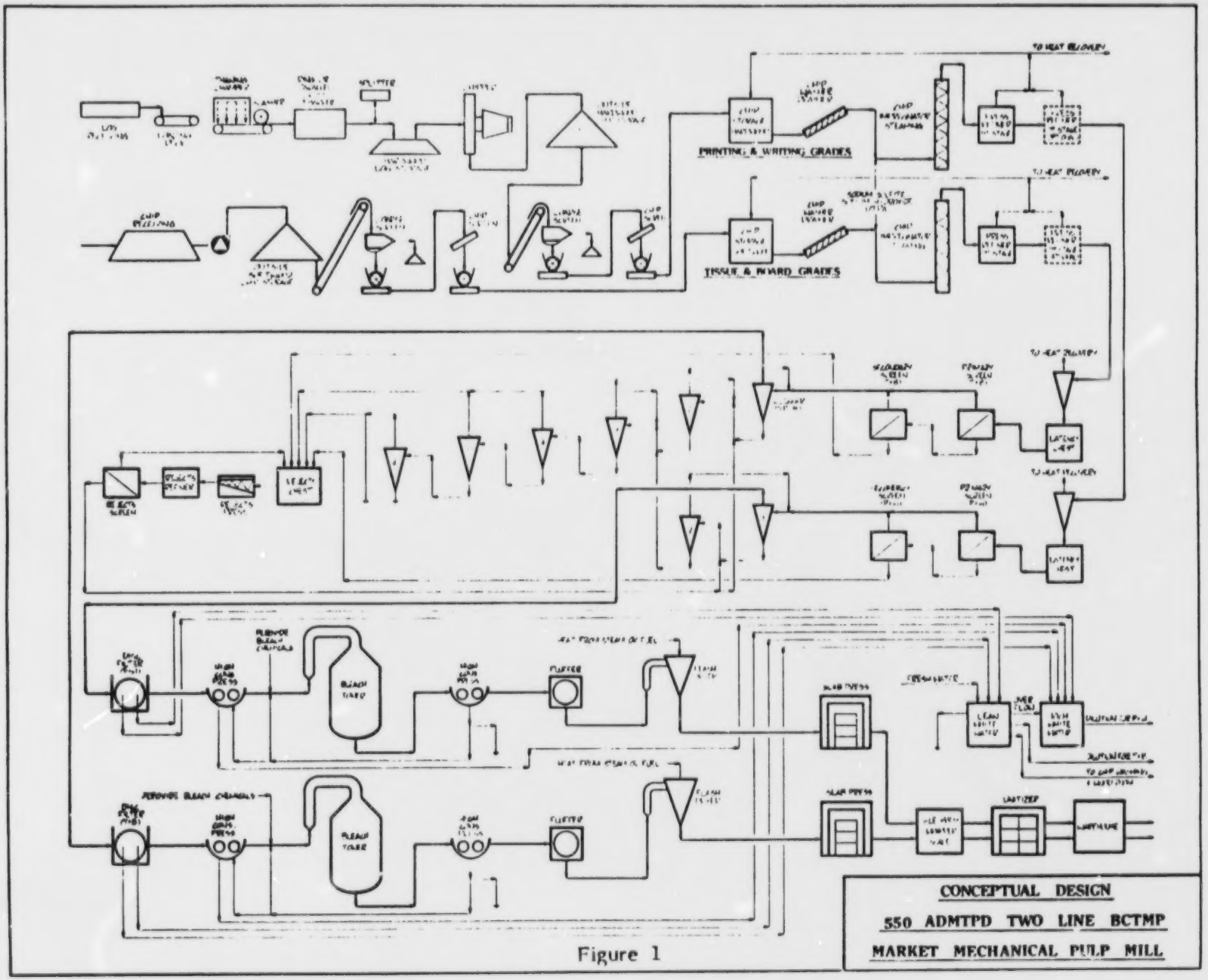
PRINTING & WRITING GRADES
TISSUE & BOARD GRADES
BLEACH TOWER
BLEACH TOWER
CONCEPTUAL DESIGN
550 ADMTPD TWO LINE BCTMP
MARKET MECHANICAL PULP MILL

Figure 1

In order to simplify the analysis of the effect of aspen decay on mill design and economics, the mill will be considered for a one-line mill. In a two-line mill with fibre transfer the finer fibres are concentrated in the printing line. It is expected that these fractions will have been affected to a greater extent by the fungi than the long fibre fractions and have a poorer bleaching response. For areas of Alberta with higher decay than used in this study (stands over 90 years old), special bleach response studies should be carried out.

Effect of Decay on Woodroom Design and Operation

The mill is designed to handle both softwood and hardwood logs. In order to optimize the system, it is necessary to segregate these species which will require separate chip piles and a reclaiming system. Since it is difficult to maintain a uniform mix of wood types from the forest, separate chip piles will be required for the sound and decayed aspen. The density of logs containing decay is lower than for sound wood. This will require slightly more capital in conveying, chipping and screening. In addition the wood requirements increase with increasing per cent decay. A conservative estimate is that total woodroom and chip storage facility costs will increase by some 15 per cent over that for sound wood or approximately $1.5 million.

The additional handling required for the decayed logs will require one additional man per shift on a two shift basis. Incremental labour requirements are included in Table 6. The chips will be metered to the pulp mill according to the product being produced. This will require more handling at the reclaim but will be within the capacity of the reclaim operator.

Effect of Aspen Decay on Pulp Mill Design and Operation

The pulp mill is designed according to the required fluid volumes or mass flows. The increase in wood to the refiners, and pulp to the bleach plant, will require slight modifications in pumping and conveying capacities; however, the costs related to these are insignificant compared to the total cost of the mill.

No additional operating costs are required except for wood and chemicals. These are discussed later. The laboratory studies indicated that the decayed wood refined more easily, i.e. required less energy. The lower specific energy requirement should balance the increase in wood being refined, thus total connected motor capacity and average specific energy consumption should not be higher for decayed wood. Labour costs will remain the same.

Screening, cleaning, reject refining and bleaching operations will not change. The longer hydraulic flow through the cleaners will require additional cleaner units. This cost is minimal. Labour will remain constant. Bleaching stained or decayed wood will require more chemicals but no change in bleaching conditions.

Flash drying and finishing will not change.

Effect of Decayed Aspen on Effluent Treatment

The effluent from CTMP contains both BOD and toxicity, and some fibre. Sedimentation is the standard treatment to remove suspended fibre and aeration in a lagoon is the standard method to reduce BOD and toxicity. Colour in bleached CTMP mills is not a major problem. Pulping decayed aspen will result in a decrease in yield which directly affects BOD loading. It is estimated that using decayed aspen will increase the capital cost of effluent treatment by 5-10 per cent or about $250,000. The major operating cost is the electrical power for aeration which increases linearly with BOD.

Summary of Mill Design

The only significant change to the operation and design of the mill to allow for the effect of stained and decayed aspen is in the wood handling. The stained and decayed wood wood is effectively treated as a separate species prior to pulping. This results in additional capital ($1.5 million) and additional labour (2 man years). The remainder of the mill would essentially operate without any additional equipment or labour.

Table 6

Unit Material and Labour Requirements/ADMT Bleached CTMP

Item	Units	Log Classification				Log Mix as in	
		Clear	Stain	Intermediate Decay	Advanced Decay	75 yr. old Stand	90 yr. old Stand
Wood	Kg BD	1,021	1,056	1,091	1,240	1,035	1,057
Pulping Chemicals	%	3.0	3.0	3.0	3.4	3.0	3.0
	Kg	29.9	30.8	30.8	37.6	30.2	30.6
Bleaching Chemicals	%	2.5	3.3	3.5	3.8	2.8	3.1
	Kg	23.6	32.0	33.9	37.5	26.6	29.8
Labour (wood handling) 1/	man days	0	2	2	2	2	2

1/ Additional to clear aspen stands.

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Chapter 6

COST OF USING STAINED AND DECAYED ASPEN

General

The decision to use aspen with stain or decay depends on a) the economic penalties incurred because of lower product quality, balanced against b) production costs, c) the costs of excluding decay on wood costs and, d) upon forest management strategy.

Mechanical type pulps are marketed according to pulp grade, i.e. printing, tissue and board, and brightness level. Standard grades based on brightness are:

70-72
75-77
78-80

Each grade commands approximately U.S.$ 25 premium in selling price over the next lower brightness grade.

Associated with wood costs are the costs of extraction and transportation. If decay is excluded, the unit cost of extraction is higher due to labour in sorting the logs and the larger area and hauling distances to obtain the required amount of timber. Offsetting these costs are lower transportation costs because of lower volumes (decayed wood has less fibre than soundwood) and lower yield losses.

Exclusion of decayed or stained wood obviously has a tremendous impact upon forest management strategy.

If decayed aspen is not used, then a large volume of wood will be wasted during the cutting period of the specific forest stand. Indications are that decay in aspen increases non-linearly with age. Examples are the 75 year old O'Chiese block with a 9 per cent decay[1/] level and the 90 year old Slave Lake - Whitecourt area with 25 per cent decay[1/] level.(4,5) Assuming a cutting period of at least 15 years for the O'Chiese block and non-use of decayed aspen, the volume losses in year one of the cycle would be 9 per cent and year fifteen, 25 per cent.

[1/] defined as intermediate and advanced decayed aspen logs

If decay is accepted, then the effect on mill operation and costs will change yearly unless there is a blend of wood from aspen stands that would keep the average age of harvest at a constant level.

Additional Manufacturing Costs for Aspen with Stain or Decay

The use of stained or decayed aspen will increase the cost of wood, pulping chemicals, bleaching chemicals, effluent handling and woodroom labour. The amounts were previously shown in Table 6; the associated costs are shown in Table 7. The cases evaluated are 100 per cent of each of the log classifications, and typical log distribution for a 75 year old and 90 year old aspen forest. The first four give the incremental effect of each classification of wood; the last two represent mature and overmature aspen stands.

The quantities of wood and chemicals listed in Table 6 are based upon results of Econotech's laboratory evaluation plus industrial experience. The wood costs used in Table 7 are $60/cunit. This value will vary according to location but is considered representative of logging cost on similar tertain in B.C. The costs for chemicals and labour are based on actual commercial operation. Chemical costs will vary depending on location, quantity and type. For example, sodium sulfite in powder form will be twice as expensive as that generated from liquid sulfur dioxide and caustic; however, the capital costs to use powdered sodium sulfite would be considerably lower.

Clear sound aspen is used as the base case, although it is not necessarily the only acceptable base economic case.

The incremental manufacturing cost/ADMT bleached CTMP for using stained and decayed logs is detailed in Table 7. For stained logs it is $25; intermediate decayed logs, $33; and advanced decayed logs, $55. Additional manufacturing costs for representative 75 and 90 year old aspen stands are $10 and $20/ADMT bleached CTMP respectively.

Revenue Penalties for Stain and Decay

As mentioned earlier, stained and decayed woods adversely affect pulp brightness. The distribution of pulp grades according to maximum practical brightness levels that each of the wood classifications would produce is estimated in Table 8. It is assumed that whereas a bleached CTMP produced from stained or decayed logs may be borderline in brightness for a grade, (for example, stained wood gives a 77.3 brightness which suits it for a 75-77 grade), proper segregation of wood in the woodroom would allow a brightness pulp to be produced a certain percentage of the time.

The penalty for using stain and decay on selling price was determined for each case, based upon a $25 difference in selling price between grades. These are shown in Table 8.

Total Cost Penalty

Operating and Revenue:

The total operating cost and revenue loss from using stained and decayed aspen logs is as follows:

Log Classification	$/ADMT Bleached Pulp
Clear	0
Stain	38
Intermediate Decay	63
Advanced Decay	85
Representative Aspen Stand	
75 year old	15
90 year old	32

This is demonstrated graphically in Figure 2.

Capital:

Capital costs for a 500 tonne/day bleached CTMP mill are approximately $120 million (excluding interest). The additional cost of using decayed aspen would be between $1.5 and $2 million, mainly for the woodroom.

Figure 2

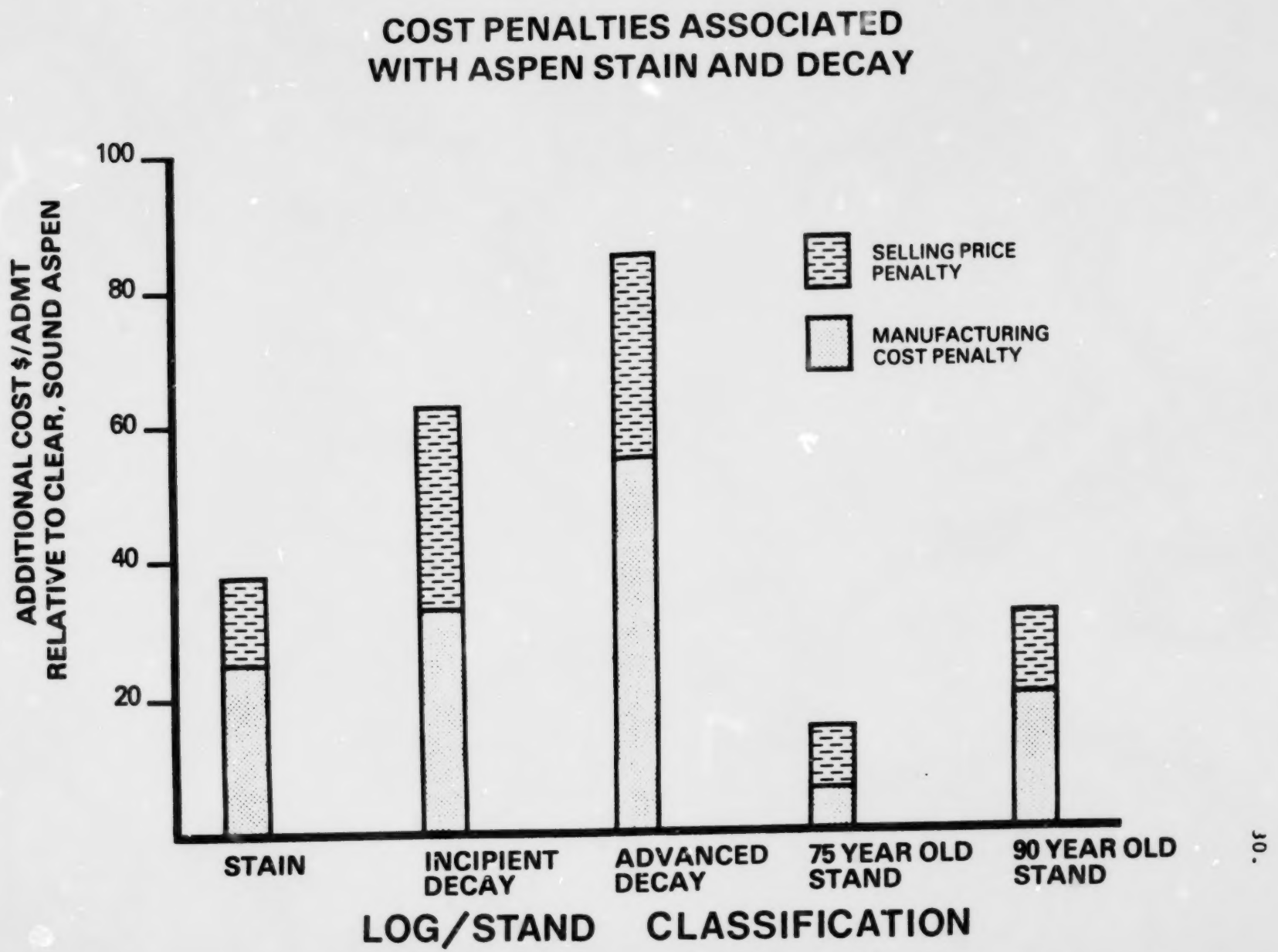
COST PENALTIES ASSOCIATED
WITH ASPEN STAIN AND DECAY
ADDITIONAL COST $/ADMT
RELATIVE TO CLEAR, SOUND ASPEN
100
80
60
40
20
SELLING PRICE
PENALTY
MANUFACTURING
COST PENALTY
STAIN
INCIPIENT
DECAY
ADVANCED
DECAY
75 YEAR OLD
STAND
90 YEAR OLD
STAND
LOG/STAND CLASSIFICATION

Table 7

Manufacturing Unit Costs/ADMT Bleached CTMP Associated with the Use of Decayed and Stained Aspen Logs

Item	Cost/Unit	Log Classification				Log Mix as in	
		Clear	Stain	Intermediate Decay	Advanced Decay	75 yr. old stand	90 yr. old stand
Materials							
Wood	$55/BDT[1/]	56.16	58.08	60.00	68.20	56.93	58.14
Pulping chemicals	$6/% on pulp[2/]	17.94	18.48	18.48	22.50	18.12	18.36
Bleaching chemicals	$27/% on pulp[2/]	63.72	86.40	91.53	101.25	71.82	80.46
Incremental effluent treatment /ADMT	$/t	0	0	0	.60	0	.05
Incremental labour/ADMT	$/t	0	0	.45	.45	.45	.45
Total of above	$	137.82	162.96	170.46	193.06	147.32	157.46
Incremental cost/ADMT		0	25.14	32.64	55.24	9.50	19.64
Rounded figures		0	25	33	55	10	20

1/ Estimate based on best available data, not to be taken as site specific.

2/ based on WRA data bank.

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Table 8

Penalty for Using Decayed and Stained Aspen Logs
Printing/Writing Grades

Cost Penalty $/ADMT bleached CTMP

Item	Log Classification				Log Mix as in	
	Clear	Stain	Intermediate Decay	Advanced Decay	75 yr. old stand	90 yr. old stand
Brightness	80	77.3	74.2	74.6	78	77
Product Mix (by brightness)						
70-72	0	0	20	20	0	0
75-77	0	50	80	80	20	50
78-80	100	50	0	0	80	50
Penalty for decay and stain - selling	0	12.50	30	30	5.00	12.50
Penalty for decay and stain - manufacturing	0	25.14	32.64	55.24	9.50	19.64
Total - penalty for using decay and stain	0	37.64	62.64	85.24	14.50	32.14
Rounded figures		38.00	63.00	85.00	15.00	32.00

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Chapter 7

CONCLUSIONS

Wood Resource

The forests of Alberta are primarily even aged, mixed hardwood-softwood, with aspen being the predominant hardwood. Mature aspen is susceptible to stain and decay, primarily due to Fomes igniarius (Linn), a white rot fungus. The stages of decay typical of these forests(4,5) and their relative percentages are:

	Log Mix as in 75 yr. stand	Log Mix as in 90 yr. stand
	per cent	
Clear Logs	72	35
Stained Logs	19	40
Intermediate decayed Logs	6	17
Advanced decayed Logs	3	8
Total	100	100

Wood Chip Characteristics

Log samples for each of the four wood classes were supplies by W.R. Dempster and Associates, and chipped by Econotech Services. Logs containing decayed wood will generate a higher fines level than sound wood. On a commercial basis it is estimated that yield loss in the woodroom would increase from 2.5 per cent for logs with only clear wood to 9.1 per cent for logs classified as advanced decay. However, accepted chips will still contain a large percentage of the original decay.

Pulp Properties

Bleached CTMP was produced from each of the four wood types by Econotech Services. The results show that the presence of decay marginally reduces unbleached pulp strengths. However, peroxide bleaching resulted in the CTMP containing decayed wood becoming virtually equivalent in strength to that containing only sound, clear aspen.

Laboratory printing studies carried out by MacMillan Bloedel Research indicate that pulp from decayed aspen should have no significant negative effects on the physical properties and printability of fine papers.

With the exception of brightness, the qualities of the bleached CTMP's from stained and decayed aspen are essentially equivalent to those from sound, clear aspen. The presence of stain and advanced decay reduced maximum pulp brightness by 3 points and 5 points respectively, but the results indicate that 75 brightness should be obtained from essentially all stained and decayed aspen logs.

Mill Design

The optimum design of a market mechanical pulp mill incorporates two pulp lines, one producing a low freeness printing/writing grade and the other a high freeness tissue and board grade. Production is 500 tonnes/day using 50 per cent aspen and 50 per cent softwood. The aspen would be primarily for the printing/writing grades. The use of decayed aspen will require approximately $1.5 million additional capital for log and chip sorting and $.5 million for effluent treatment and minor changes in the pulp mill. Stained and decayed aspen is essentially treated as a separate species for wood handling, but no other significant design modifications or capital costs are necessary.

Cost Analysis

The cost of using stained and decayed aspen is a result of increased capital costs, wood costs, operating costs and decreased selling prices. The additional capital cost is estimated to be less than 2 per cent of that using only sound, clear wood. The penalties associated with manufacturing and selling for wood mixtures representing 75 and 90 year old stands are:

Cost Penalty	75 yr. wood	90 yr. wood
	$/ADMT bleached CTMP	
Manufacturing	10.00	20.00
Selling	5.00	12.00
Total	15.00	32.00

These penalties are relative to sound, clear aspen which is a very desirable wood source for bleached CTMP.

Measurement of Decay

The nature of the attack on wood by white rot fungi, the prevalent fungi type in Alberta's aspen forests, is such that physical and chemical tests are not sufficiently sensitive to determine level of decay or stain with any degree of accuracy. Visual methods are superior and, based on the results of this study, sufficient.

Chapter 8

RECOMMENDATIONS

There are four specific recommendations that basically represent limitations in the application of the results and conclusions from this study. Each of these recommendations covers a different area and includes forest management, wood cost analysis, base case economics and effects of other decay and stain types.

Forest Management

Prior to any meaningful feasibility analysis for utilizing aspen from a specific site for bleached CTMP, alternative aspen cutting schedules should be analyzed. The cost associated with stain and decay increases with the age of the aspen stand. A high grading cutting schedule (i.e. according to age) could result in a very profitable situation for a pulp mill followed by an unprofitable period if only overmature aspen stands remain.

The results of this study indicate that aspen stands up to 90 years old should at this stage be considered economically viable for bleached CTMP.

Wood Cost Analysis

The cost of using stained and decayed aspen relative to sound, clear aspen has been identified in this study. However, there is an alternative to using decayed aspen — leave it in the forests. To evaluate these alternatives it is necessary to determine wood costs for completely logging and transporting an aspen stand to a manufacturing site compared with complete logging and selective transportation (i.e. leaving badly decayed logs in forest).

It is probable that a site specific location should be used for this analysis.

Base Case Economics

All cost penalties in this study were determined relative to sound, clear aspen. This could present too conservative an economic scenario for stained and decayed aspen. Aside from the cost of wood, the cost of producing bleached CTMP from sound, clear aspen should be less than that from sound softwood. Aspen has a superior bleaching response compared to softwoods. A detailed bleaching evaluation comparing CTMP's from sound, clear aspen and from a representative Alberta softwood sample should be carried out.

Fungi and Stain Types

The analysis in this study is based on stain and decay generated by one particular (but most prevalent) white rot fungus. Although it is unlikely that other white rot fungi would give any meaningful difference in results, there are other types of stain. It is recommended that the stain classified as wet wood stain be evaluated for at least bleaching response.

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GLOSSARY

AD	air dry (10% moisture)
ADMT	air dried metric ton - market pulp is priced on an air dry (10% moisture) basis
BD	bone dry (0% moisture)
BOD	biochemical oxygen demand
CTMP	chemi-thermomechanical pulp
fines	usually defined as fibres that pass through a 200 mesh screen
freeness	a characteristic of pulp usually associated with fibre length and drainage
wood free	pertaining to papers made from chemical pulp

Section II

WOOD PROCUREMENT AND LABORATORY EVALUATION

Chapter 9

THE EFFECT OF ROT AND DEFECT ON THE PRODUCTION, QUALITY AND COST OF ASPEN BLEACHED CTMP

WOOD PROCUREMENT

December, 1982

METHODS

December 8, 1982, trees were sampled from three deciduous stands* where the predominant species was trembling aspen Populus tremuloides Michx. These stands fall within the B.18a Mixedwood Section of the Boreal Forest Region, as classified by Rowe**. The selected stands were considered by staff of Blue Ridge Lumber as representative of the Company's available aspen inventory. The first two stands were 100 years old with a high basal-area stocking level of about 50 square metres per hectare. They were characterized by a high level of decay. A third 55 year old stand with a basal-area stocking of 35 to 40 square metres per hectare, was also sampled. Fungal fruiting bodies of Fomes igniarius (Linn.) Fr. were present in all stands and occurred on sample trees 1, 2 and 3 (see Appendix 1). This species is the predominant cause of heart rot in aspen in Alberta.

Live trees were selected and felled. Diameter and total height were recorded. Each tree was then cut into sections 125 cm in length. Crotches and crooks were avoided. Sections were numbered from the base of the tree. Each section was classified as follows, according to the predominant appearance of the exposed ends:

C Clear
S Stain or incipient decay
I Intermediate decay
A Advanced decay

The terms incipient, intermediate and advanced decay are defined by the Canadian Nation Standard for scaling roundwood (see Appendix 3). Note that the Standard does not define "stain", but that incipient decay is recognized in terms of discoloration only. Samples were frozen; therefore classification was strictly visual, and checks for hardness could not be made. The "Clear" class was intended to include wood with no decay or stain; however, some traces of discoloration could not be avoided. Most stain encountered

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* Legal description for the locations of the stands 1,2, and 3 respectively:

LSD1-8-62-10-W5
LSD7-9-62-10-W5 and
LSD7-25-60-11-W5 (approx. 100 miles northwest of Edmonton, Alberta)

** Rowe, J.S. 1972. "Forest Regions of Canada" Dept. of Fisheries and the Environment, Canadian Forestry Service Publ. No. 1300

was associated with decay columns rather than independent "wetwood". As is characteristic of Fomes igniarius, most decay, even in the advanced state, is restricted to the heartwood. The characteristic advance of the decay in aspen does not lend itself to discrete classes applying to entire stem cross-sections. The samples obtained represent various stages in a continuous process. This process is such that the occurence of more than one class of decay in representative tree cross-sections is inevitable.

Felling was continued until at least four sections were obtained within each of the four decay classes. Four sections from each class were then retained. Each retained 125cm section was divided into three sub-samples which were cut and shipped as follows

- a 60cm length to Econotech (coded as "a"),
- a 5cm central slab to Alberta Research Council (ARC),
- a 60cm length to ARC (coded as "b").

Sub-samples were marked according to tree number, section number, and decay class. Sub-samples a and b were scaled for gross volume and decay (advanced and intermediate combined). Gross and defect volume were defined and measured according to the CSA standard (see Appendix 3). Data for these sub-samples are included in Appendix 2.

Appendix 1

Stand-origin, diameter, and height of sampled trees

Stand #	Tree #	dbh* (cm)	Total height (m)
1	1	23.5	22.4
	2	21.0	20.6
2	3	22.4	25.0
	4	22.9	25.5
3	5	20.7	21.5
	6	22.1	21.5

* Diameter breast-height over-bark

Note: Stands 1 and 2 are approximately 100 years old and have a basal-area stocking of about 50 square m per ha. Stand 3 is approximately 55 years old and averages 35 to 40 square m per ha. All are deciduous stands occuring in the B.18a Mixedwood Section of the Boreal Forest Region.

Appendix 2

Scaled volume and defect of roundwood samples

Class	Tree#	Section #	Sub-sample	Gross vol.* (cu.m x 10^5)	Defect vol.** (cu.m x 10^5)	% decay
A	1	4	a	1961	999	50.9
			b	2000	971	48.6
A	1	5	a	1793	912	50.9
			b	1774	774	43.6
A	2	5	a	1291	495	38.3.
			b	1323	557	42.1
A	4	5	a	1604	610	38.0
			b	1756	662	37.7
I	1	7	a	1597	367	23.0
			b	1518	137	9.0
I	2	7	a	910	83	9.1
			b	1012	190	18.8
I	3	10	a	1118	170	15.2
			b	1199	248	20.7
I	4	9	a	1141	131	11.5
			b	1229	194	15.8
S	2	1	a	1802	16	0.9
			b	1736	4	0.2
S	2	2	a	1606	0	0
			b	1570	0	0
S	3	3	a	1755	0	0
			b	1895	0	0
S	6	3	a	1857	0	0
			b	1810	0	0
C	5	2	a	1746	0	0
			b	1648	0	0
C	5	3	a	1587	0	0
			b	1510	0	0
C	5	6	a	1229	0	0
			b	1154	0	0
C	6	8	a	1223	0	0
			b	1222	0	0

* Total volume inside-bark
** Combined advanced and intermediate decay

Appendix 3

Definitions used in decay classification and roundwood scaling*

Decay means the decomposition of wood substance caused by the action of wood-destroying fungi, resulting in softening, loss of strength and mass, and often in change of texture and color.

Advanced decay means the late stage of decay in which the decomposition is readily recognized as the wood becomes punky, soft, stringy, pitted or crumbly.

Incipient decay means the early stage of decay in which the decomposition has not proceeded far enough to soften or otherwise change the hardness of the wood perceptibly. It is usually accompanied by a slight discoloration of the wood.

Intermediate decay means a more advanced stage of decay than incipient decay characterized by a change in the color of the wood and some slight decomposition and loss of strength which, however, do not render the wood unfit for general purposes.

Defect volume The formula used to calculate defect volume shall be that for the geometric solid which nearest approaches the shape of the defect. Smalian's formula ..... shall be used to calculate the volume of wood inside sap rot and the volume of heart rot showing at both ends of the log.

* From CSA Standard CAN3-0302.1-M77

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Chapter 10

LABORATORY PULPING AND BLEACHING EVALUATION

REPORT TO

ALBERTA RESEARCH COUNCIL

THE EFFECT OF ROT AND DEFECT ON THE PRODUCTION, QUALITY AND COST OF ASPEN BLEACHED CTMP

by

ECONOTECH SERVICES LIMITED

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THE EFFECT OF ROT AND DEFECT ON THE PRODUCTION, QUALITY AND COST OF ASPEN BLEACHED CTMP

I. SUMMARY

Four samples of log bolts were received from W.R. Dempster and Associates Ltd. categorized as clear, stained, intermediate decay and advanced decay. These samples were hand debarked, chipped and screened into different sizes. Each chip size was characterized for the percent decayed material by visual examination. The chip fractions passing through a 7/8" screen and retained on a 3/8" screen were used for processing by the chemimechanical pulping process which involved a chemical treatment with 15% sodium sulphite solution at 120°C for 15 minutes. The cooked chips were processed in a laboratory refiner with samples removed at different freeness levels ranging from 400 to 200. The lowest freeness pulp from each of the four wood categories was bleached with hydrogen peroxide and evaluated for brightness and paper making properties. The unbleached pulps at different freeness levels were also evaluated for paper making properties. The yield in the chemimechanical pulping process was determined by separate, small-scale cooks followed by defibering in a Waring blender with hot water. The chemical consumptions in each stage of processing were measured and the unbleached pulps were tested for bound sulphur content. The results are analyzed in detail to show the effect of the different types of wood on processing yield, chemical usages and paper strength properties. The comparisons are shown in numerous tables. The effects of wood defects on pulp mill raw material usage and productivity are shown. The results are compared with results previously obtained by Econotech in a study carried out for Alberta Forest Service reported in March 1982.

II. CONCLUSIONS

1. The logs classified as clear contained no rot and very little stain, the logs classified as stained contained 0.8% decay, as intermediate decay - 6.6% decay, as advanced decay - 33.8% decay.
2. The -3/16" chip fines fraction contained more decayed wood than the other chip fractions. The -3/8, +3/16" pin chips also contained more decay than the other chip fractions.
3. It does not appear to be economically attractive to discard the -3/8, +3/16" pin chip fractions from a furnish as a way of decreasing the amount of decayed material since a large amount of material would have to be discarded and insignificant improvements in product quality would be obtained.
4. The 1% hot caustic solubility of the chips was not a good indicator of the amount of decay present.
5. The advanced decay chips consumed slightly more sodium sulphite during the CTMP processing and gave a significantly higher bound sulphur content on the pulp (0.26% versus 0.11% for the pulp from clear wood).

It was calculated that the actual 30% decayed wood in the "advanced decay" wood sample would have a bound sulphur of 0.55% to give the value of 0.26% on the overall pulp. The decayed wood must react more readily during the sulphiting step of the process and this is probably a key factor in overcoming the problems of lower strength and lower brightness for the decayed wood.

6. The yield in the CTMP processing is lower for the advanced decay sample which again indicates greater reaction and removal of detrimental material.

7. The pulps bleached quite readily with peroxide using 3% for the clear wood and 4% for the stained and decayed wood samples. The brightness gain was up to 24.8 units and all of the pulps gave brightnesses higher than 70.

8. The pulp strength properties (summarized in Table IV) show that the unbleached pulps from advanced decay chips had very good strength properties, essentially equivalent to the pulp from the clear wood. These good strength properties were probably caused by the increased chemical reaction during the processing as indicated by the high bound sulphur. Literature data indicate that increased chemical reaction improves pulp strength properties. The unbleached pulps from the stained wood and the wood with intermediate decay had lower paper strengths than for the clear wood or the advanced decay wood pulps.

9. Bleaching the CTMP pulps gave large improvements in all of the strength properties and produced very good pulps. The increase in strength properties was least for the advanced decay pulp and it ended up with lower tear and tensile than the pulps from the other three wood categories.

10. The overall yield of bleached CTMP pulp from wood was 90.5% for clear, 87.3% for stained, 86.9% for intermediate decay and 77.8% for advanced decay. These yields are based on rechipping the +1 1/8" oversized chips, use of the +7/8" large chips and retaining the -3/8,+3/16" pin chips in the furnish.

11. The results obtained in this project are consistent with the results obtained in the previous work for Alberta Forest Service. The samples used in the previous project were enriched with decay to 61% for the advanced decay sample and 35% decay for the incipient decay sample, so larger effects were seen. The previous work, carried out in a different refiner, produced pulps with lower bulk,

higher burst and tensile and lower tear than the results obtained in this study. A conclusion of that project was that the average amount of decay and stain in the O'Chiese aspen would not cause a significant problem for a bleached CTMP mill.

12. Use of 100% logs categorized as having advanced decay (30% actual decayed wood) would result in significant increases in wood usage, cooking chemical usage and bleaching chemical usage in a pulp mill. The production capacity of the equipment in the early stages of processing would be decreased because of the decreased yield.

13. A typical aspen log harvest containing 20% stain and 10% decay could be used in a bleached CTMP mill with minimal effects on raw material usage and mill production capacity.

14. The bleached CTMP process is ideally suited for use on decadent aspen stands since the process gives extra chemical reaction with the decadent wood to overcome to a large degree, its problems of lower strength and lower brightness.

III. RECOMMENDATIONS

1. The bleached CTMP process should be used to process aspen containing stain and decay since it "upgrades" the defective wood, but kraft and TMP do not.
2. Work should be carried out on the production of CTMP pulp from mixtures of softwoods and hardwoods, processed together or separately.
3. Work should be carried out to determine the effect of pulp bound sulphur content on the pulp properties obtainable from clear wood, stained wood and decayed wood. This should include mixtures of the wood types processed together to show the preferential reaction with stained or decayed wood.
4. Work should be carried out to determine the effects of -3/8, +3/16" pin chips from decayed wood on CTMP pulp strengths and brightnesses.
5. A project should be carried out to determine the quality of bleached CTMP that can be produced from decadent softwoods including that from rot, spruce budworm and beetle kill, and fire damage.
6. The effects of the degree of chemical treatment (% Na_2SO_3, temperature, time and pH) in CTMP should be studied for sound and decadent aspen relative to product paper strengths, brightness, opacity and yield.

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IV. INTRODUCTION

There are very large stands of aspen (populus tremuloides) in Alberta and other parts of Canada which are not being utilized. The aspen contains considerable amounts of stain and decay which can affect the pulp quality, yield and processing costs. A previous study carried out by Econotech as part of a joint study with Pedology Consultants for Alberta Forest Service reported in March 1982 (the O'Chiese Block Study) showed the effects of stain and decay on the use of the aspen for kraft, thermomechanical, and bleached chemimechanical pulping (BCMP). That study showed that the BCMP process would produce a very good pulp from aspen and would overcome some of the problems caused by stain and decay in the aspen. The stain and decay caused loss of pulp brightness and some loss in strength properties. However, since the O'Chiese block aspen contains only 8.7% decay and 19% stain, it should be possible to accept "woods run" aspen for use in the bleached CTMP process without serious loss in pulp properties. Some adjustment in processing conditions and the amount of bleaching chemical would be required to overcome the problems. Further work was needed to study the suitability of stained and decayed aspen for bleached CTMP pulping with regard to pulp yield, pulping chemical usages and pulp mill processing costs. Additional work was also needed to determine if some of the decayed wood could be removed during chipping and chip screening to upgrade the chip furnish obtained from decadent aspen.

Econotech Services Limited has carried out many projects on mechanical pulping of softwoods and hardwoods, and did the first feasibility study for the Quesnel River TMP and CMP softwood mill. Econotech carries out evaluation on mechanical pulps produced in mills from around the world.

V. EXPERIMENTAL METHODS AND RESULTS

A. Chip Sample Preparation

Samples of aspen logs were obtained by W.R. Dempster and Associates from the Boreal forest region. The four samples (four logs per sample) were labelled clear, stained, intermediate decay and advanced decay. Photographs of the log samples are in the appendix. The log samples contained Fomes igniarius (Linn.). The pictures of the ends of the logs show that the separation into the different categories was not 100%, i.e. the stained and decayed logs contained a considerable amount of clear wood. These logs were felt to be typical logs in their category so it was decided to process the logs through the chipping and screening operation "as-is" without slabbing off the outer clear wood as was done in the previous study for Alberta Forest Service.

The logs were hand debarked and run through the Econotech chipper with the blowing vanes installed to impart more mechanical action to the chips. The chips from each of the categories were given a Williams screen classification and the results are shown in Table I. The material with decay generated more fines (-3/16") and pin chips (-3/8, +3/16") during chipping. The percent rot on each of the chip fractions was visually estimated and the results are shown in Table I. The data show that the fines and pin chip fractions contained a higher percentage rot than the rest of the furnish.

One percent caustic solubility tests were carried out on some of the chip fractions and the results are shown in Table I. These data show some increase in caustic solubility for the fractions with a high rot content but the

differences were not large enough to indicate that this test can be used to measure the percent decay in a chip furnish.

The total percent rot (decay) for each of the categories of wood are shown under the total for the Williams classification and show 0% rot in the clear wood, 0.8% in the stained wood sample, 6.6% in the intermediate decay sample and 33.8% in the advanced decay sample.

The chips that were selected for use in this project were the size that passed through the 7/8" chip screen and were retained on the 3/8" screen (-7/8, +3/8"). The +7/8" chips were not used because the larger size might produce more variability in the pulps produced in the small refiner. This larger chip fraction would be used in a mill operation. The -3/8,3/16" pin chip fractions were rejected in this study in an attempt to remove additional rot from the furnish. The advantages of this are discussed in Section VI. The chip densities uncompacted and compacted are shown in Table I and indicate that the intermediate decay and advanced decay chip samples had lower chip bulk density, which would result in a slight decrease in capacity in the chip handling and chip processing equipment. The wood brightnesses were lower for the chip samples containing stain and decay.

B. CTMP Processing

The CTMP conditions used on each of the four chip categories were as follows:

1. 30 minute atmospheric steaming in a 20 litre stainless steel digester.

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2. Chemical treatment with a 15% sodium sulphite solution at pH 8.0 for 15 minutes at 125°C and 20 psig in a 20 litre stainless steel pressure vessel.
3. Disc refining in a Sprout Waldron 12 inch refiner equipped with a motor driven screw feed and with steam and hot water heating and purging flows. The plate clearances for the refining were 0.040" for the first pass, 0.020" for the second pass and 0.010" for the subsequent passes.

The CTMP conditions are shown in Table II. Pulp samples were removed at different freenesses between passes. The pulps were tested for freeness, strength properties and Bauer McNett classification. The results are shown in Table III and in the beater curves in the appendix.

C. CTMP Bleaching

The unbleached CTMP pulps with freenesses of about 200 from each of the four chip categories were bleached using alkaline hydrogen peroxide with sodium silicate as a protector. The pulp was pretreated with 0.5% DTPA (diethylenetriamine pentaacetic acid) to remove metallic ions that could interfere with the peroxide bleaching. The bleaching conditions and results are shown in Table II.

Tables IV and V summarize the pulp properties for the unbleached and the bleached pulps. The results show a very large increase in strength properties for each pulp when it was bleached.

Samples of bleached pulp from the clear wood and the advanced decay wood were sent to MacMillan Bloedel Research for printability testing.

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VI. DISCUSSION

A. Wood Quality and Chip Screening

The chip properties are shown in Table I. The results showed that the amount of rot was zero in the clear wood sample, 0.8% in the stained wood sample, 6.6% in the intermediate decay and 33.8% in the advanced decay. The -3/16" chip screening fines and the -3/8,+3/16" pin chips had higher percentages of decay than the other fractions. The chip furnish used in this study did not include the -3/8, +3/16" pin chips, since it was felt that rejecting this material would decrease the rot content of the chips by a significant amount. However, this would result in a substantial decrease in chip screening yield, especially if the same set of screens were used to screen the clear, stained, intermediate decay and advanced decay chips. Table VI shows the calculated chip rot content for different chip screening alternatives. Based on the results obtained in this project, it does not appear worthwhile to reject the -3/8, 3/16" pin chips from any of the chip furnishes as a way of decreasing the rot content. Further work would be beneficial to confirm this, especially on the effect of the pin chips on pulp brightness and strength properties.

The wood brightnesses obtained on ground chip samples from each category showed that the stained, intermediate and advanced decay chips had decreased brightness caused by the presence of stain and decay.

The 1% caustic solubility of wood chips has sometimes been used as an indication of the amount of decay in the chip furnish. The results on different chip fractions shown in Table I indicate that there is some increase in caustic solubility with the presence of decay, but the

differences are so small that this test does not appear to be a useful method for categorizing mill chips for the percent decay.

B. CTMP Processing

The CTMP processing conditions are shown in Table II. All of the four aspen samples processed quite well by the CTMP processing conditions used in this study. A large excess of sodium sulphite was used for the chemical pretreatment and less would be required in a mill operation.

Table II also shows figures for estimated pulp yield after the CTMP cooking and refining. These yields were obtained by carrying out separate cooks in small bombs on 120 o.d. grams of chips cooked for 15 minutes at 125°C with 15% sodium sulphite solution. The cooked chips were ground up in a Waring blender, washed with boiling water and dried to determine the yield. This method of yield determination is much more accurate than trying to collect all of the pulp from runs in the disc refiner. The pulping yield data show a decrease for the advanced decay sample.

Data for bound sulphur in the CTMP pulps are shown in Table II. These results show an increase in bound sulphur for the stained, intermediate and advanced decay samples. This is probably because the decayed wood is more

accessible and more reactive with the sodium sulphite. Since the chip sample labelled as advanced decay contained about 30% decay and the rest was stained or sound wood, it can be calculated that pulp from 100% decayed chips would have a bound sulphur of about 0.55%. This higher degree of chemical reaction with the decayed wood was very beneficial in overcoming the decreased wood brightness and the lower strength of this wood. Published data show that increased chemical treatment increases pulp strength.

Table III shows the pulp properties for the unbleached pulps at several freeness levels and also reports the number of refiner passes required to obtain each freeness level. The pulp from the advanced decay sample took fewer refiner passes to reach 200 freeness than the other samples. This is probably because of some degradation of the wood due to the decay and the increased chemical reaction for this material.

C. Pulp Bleaching

The pulp bleaching conditions and results are shown in Table II. The pulp was treated with 0.5% DTPA prior to peroxide bleaching to remove any metallic ions that might decompose the peroxide in the bleaching. The bleaches were carried out using either 3 or 4% hydrogen peroxide for 3 hours at 60°C and 10% consistency. The residual peroxide data indicates that 70-80% of the peroxide was consumed. Residual peroxide could be recovered by recycling in a mill operation and thereby decrease the requirement for peroxide chemical. The brightness gain in the bleaching was very good, especially for the lower brightness samples of stained and decayed wood. The bleaching yield was lower for the advanced decay pulp sample.

D. Processing Yield

Table VII shows the processing yield for each type of wood sample and gives results for the cases with the -3/8,+3/16" pin chips discarded or with them accepted. Pin chips were rejected in this project as a method of decreasing the rot content, but as pointed out earlier, it had only a minor effect on the rot content of the accepted materials and would result in a marked decrease in the screening yield. For the yield data in Table VII, it is assumed that the +1 1/8" chip fractions would be rechipped, generating some pin chips and fines which would be removed in subsequent screening. Rechipping recovery is lower for the case where the pin chips are not accepted and also the estimated rechipping recovery is lower for the samples with stain and decay because more fines would be generated. The chipping yield shown in the table is a recovery from our chipper and shows a small loss of dust from the operation which was about the same for all the samples.

The advanced decay chip sample gave lower yields for screening, CTMP processing and bleaching. If we assume that the -3/8,+3/16" materials are not rejected, the overall yield of bleached CTMP from o.d. peeled logs would be 90.5% for the clear wood, 87.3% for the stained sample, 86.9% for the intermediate decay sample and 77.8% for the advanced decay sample. It was calculated that a sample containing 100% advanced decay would give an overall yield of about 50%.

E. Paper Making Properties

The paper making properties of the unbleached and bleached pulps from each of the categories of wood are summarized in Table IV and V. The data are also shown in Figure 1 along

with the data from the previous study carried out for Alberta Forest Service. The comparison with the previous work will be discussed in more detail in the next subsection.

Table IV is a summary of the unbleached pulp properties at three different freenesses and the bleached pulp properties at 1 freeness. The data on the unbleached pulps show that the CTMP pulp prepared from chips with advanced decay had very good strength properties almost equivalent to the pulp prepared from the clear aspen. The advanced decay pulp was better than the pulps prepared from stained and intermediate decay chips. As previously pointed out, the higher strength of the pulp from the advanced decay is probably caused by the greater degree of chemical reaction by the decayed material as indicated by the higher bound sulphur value. It was calculated that the bound sulphur on the decayed material in this sample (30% of the chips) would be about five times as high as the bound sulphur on the clear wood (.55% versus .11%). Bleaching the pulps increased the strength properties of all of the pulps but the increase was less for the pulp prepared from the chips with advanced decay. This bleached pulp had lower tear and tensile than all of the other bleached pulps - 10% lower than the pulp from the clear aspen chips.

Samples of handsheets prepared from the different bleached pulps are included in the appendix to this report. Unbleached pulp prepared from the chips with advanced decay has more dirt particles than the other unbleached pulps but this does not show in the bleached pulp sample.

F. Comparison of Results Obtained in this Project with Those Obtained in Previous Work for Alberta Forest Service

Tables VIII, IX and X are copies of tables in the report to Alberta Forest Service dated March 1982. Figure 1 is a graph of strength properties versus percent visual decay using data from both projects. In the previous project, the logs were split or cut with a band saw to obtain fractions that were very high in decay or stain. This gave much greater enrichment of decay in the samples labelled advanced and incipient decay (61% in the advanced and 35% in the incipient decay sample). The higher level of decay in the previous chip samples lead to greater decreases in brightness and tear strength than were obtained in this current project which had only 30% decay in the advanced decay sample. The strength test data show very little loss in burst and tensile strength, even with 60% decay in the chip sample used.

The previous study for Alberta Forest Service (Pedology) was carried out on a different wood sample and with a different laboratory refiner. One or both of these changes resulted in pulps that had substantially lower bulk than obtained in the present project, which resulted in higher burst and tensile and lower tear values. Comparing the pulps at the same bulk would give closer comparison on burst, tear and tensile strength values.

Table IX summarizes the data from the previous project that were obtained for kraft pulp and thermomechanical pulp.

Table X shows the effect of various levels of actual stain and decay in a chip furnish on kraft, thermomechanical and bleached chemimechanical pulp. The bottom line in the table shows the effects of the average level of stain and decay in the O'Chiese area. It can be seen that the loss in strength properties for the decay and stain is least for the bleached chemimechanical pulp, which is a reflection of the ability of this process to give an increased chemical treatment to the decayed wood to overcome the strength loss. A conclusion of the previous project was that the average level of stain and decay in the O'Chiese block would not have a serious detrimental effect on bleached chemimechanical pulp but that care would have to be taken at a CTMP mill to avoid periods of chip feed containing very high levels of stain or decay.

G. Mill Cost Factors

The use of aspen logs containing stain and decay as part of the furnish for a bleached CTMP mill has been shown to have a minimal effect on pulp quality as long as the amount of decay is controlled to the normal average amounts found in timber stands. However, the use of logs containing stain and decay would slightly increase the raw material usage for the bleached CTMP mill and would slightly reduce the operating capacity of the mill because of the lower processing yield that is obtained. Table XI is a summary of the effects of the presence of stain and decay on mill operating costs and production rate. The table shows that if the mill ran on 100% logs classified as advanced decay (containing about 30% decay) it would have the following effects relative to running on 100% clear wood:

Wood requirement: 1157 kg/ton of pulp vs. 994 kg/ton of pulp

Sodium sulphite usage in cooking: 108 kg/ton of pulp vs. 88 kg/ton

Hydrogen peroxide bleaching chemical usage: 3.3 kg/ton of pulp vs. 2.2 kg/ton

Production capacity reduced to 86% in chipping and chip screening, 90% in cooking and refining, and 95% in bleaching. The effects for wood classified as intermediate decay or stained would be less than for the advanced decay sample.

Table XI also contains calculated values for a furnish containing 70% wood classified as clear, 20% wood classified as stained and 10% of the wood classified as advanced decay. It should be pointed out that the wood classified as stained probably only had about 50% stained wood and the wood classified as advanced decay contained 30% actual decay. The numbers calculated for this furnish, which might be obtained at a CTMP mill, show that the effect on raw material costs and productivity would be minimal.

Care should be taken in discussing the amount of rotten logs in a given mill furnish or timber stand as to whether the amount of decay is based on the percentage of trees or logs classified as "decayed" (which might only contain 30% decayed wood) or whether it refers to the actual percent of decay in the furnish. The same is true for the classification as "stained logs".

TABLE I

CHIP PROPERTIES

Wood Log Classification	Clear		Stained		Intermediate Decay		Advanced Decay	
Chipping Yield, %	99.4		99.3		99.5		99.5	
Williams Classification	%	Rot %	%	Rot %	%	Rot %	%	Rot %
+1 1/8"	4.8	0	6.1	0	7.1	2.1	4.7	26.0
+ 7/8"	30.6	0	20.4	0.2	26.0	4.2	16.8	18.3
+ 5/8"	40.4	0	38.8	0.7	37.8	7.3	31.8	22.4
+ 3/8"	19.1	0	24.8	1.7	21.0	7.6	28.3	39.7
+ 3/16"	4.3	0	8.5	0.4	6.3	14.0	13.3	49.4
- 3/16"	0.8	0	1.4	0	1.8	*15	5.1	*90
Total	100	0	100	0.8	100	6.6	100	33.8
Accepts -7/8",+3/8"								
Chip Density, g/cc								
Uncompacted	0.285		0.297		0.267		0.242	
Compacted	0.299		0.306		0.275		0.250	
Oven Dry, %	50.1		46.9		51.1		51.3	
Visual Rot, %	0		1.1		7.4		30.5	
Wood Brightness	65.5		53.8		57.2		49.6	
1% Caustic Solubility, %								
-7/8", +3/8" fraction	22.3		20.5		20.8		22.3	
+3/16" fraction	22.5		21.0		21.9		24.5	
-3/16" fraction	27.3		23.8		26.1		28.8	

*Approximate % rot on -3/16" fraction

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TABLE II

CTMP CONDITIONS

Wood Log Classification	Clear	Stained	Intermediate Decay	Advanced Decay
Atmospheric Presteaming, Minutes	30			
Chemical Charge				
Na_2SO_3 solution, %	15			
gpl	170			
pH	8.0			
Cooking				
Temperature, °C	125			
Time to, min.	9	7	9	7
Time at, min.	15			
Final pH	7.3	7.4	7.4	7.4
Residual Na_2SO_3, gpl	124.2	124.0	125.6	113.0
Na_2SO_3 consumed, % on O.D. chips	7.6	7.7	6.7	8.6
Refining Plate Clearances				
1st pass	.040"			
2nd pass	.020"			
Subsequent passes	.010"			
Estimated Yield, %	94.6	94.5	94.7	89.4
Bound Sulphur, % on pulp	0.11	0.16	0.20	0.26
Bleaching				
H_2O_2, %	3	4	4	4
Silicate, %	5	5	5	5
Total Alkalinity, %	3.8	4.5	4.5	4.5
Final pH	10.3	10.5	10.5	10.5
Residual, % of applied	29	28	25	19
Unbleached Brightness	60.7	53.2	51.6	49.8
Bleached Brightness	79.9	77.3	74.2	74.6
Brightness Gain	19.2	23.9	22.6	24.8
Bleaching Yield, %	97.5	94.8	94.7	92.9

Bleaching Pretreatment: 0.5% DTPA
Bleaching Conditions: 3 hr, 60°C, 10% Consistency

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TABLE IIIA

PROPERTIES FOR PULP FROM DIFFERENT WOOD LOG CLASSIFICATIONS

Wood Log Classification	CLEAR R-21					ADVANCED R-24			
	UNBLEACHED				BLEACHED	UNBLEACHED			BLEACHED
REFINER PASSES	5	9	10	13	13	5	6	9	9
PHYSICAL PROPERTIES									
C.S. Freeness, post latency, mls	583	428	309	213	151	410	263	197	184
Bulk, cc/g	3.08	2.68	2.44	2.40	1.70	2.51	2.47	2.42	1.74
Burst Factor	7	11	14	15	28	12	13	15	27
Tear Factor	29	45	50	50	65	43	43	48	59
Tensile, meters	2122	3052	3490	3835	5694	3083	3366	3918	5229
Pulmac Rejects, (+0.006), %		0.01	<0.01	<0.01	<0.01	0.04	0.01	<0.01	<0.01
BAUER McNETT FIBER CLASSIFICATION									
+ 14 mesh %	-	<0.1	0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1
+ 28 mesh %	-	11.4	10.4	6.5	4.5	9.5	8.2	6.2	5.0
+ 48 mesh %	-	46.7	45.6	41.1	39.2	46.2	44.1	41.1	44.9
+100 mesh %	-	19.4	21.5	24.2	24.3	23.9	23.6	23.4	24.2
+200 mesh %	-	6.2	6.8	10.2	12.7	7.4	9.4	8.1	8.0
Total retained +200 mesh %	-	83.7	84.4	82.0	80.7	87.0	85.4	78.9	82.1
Fines through 200 mesh %	-	16.3	15.6	18.0	19.3	13.0	14.6	21.1	17.9
OPTICAL PROPERTIES									
Opacity, TAPPI, Elrepho %	-	93.1	93.2	94.7	81.5	95.5	95.7	96.4	83.6
Brightness, TAPPI, Elrepho, %				60.7	79.9			49.8	74.6
Bleaching Yield, %					97.5				92.9

TABLE IIIB

PROPERTIES FOR PULP FROM DIFFERENT WOOD LOG CLASSIFICATIONS

Wood Log Classification		STAINED R-22					INTERMEDIATE R-23				
		UNBLEACHED				BLEACHED	UNBLEACHED				BLEACHED
REFINER PASSES		5	6	8	11	11	6	7	10	13	13
C.S. Freeness, post latency, mLs		445	375	301	203	154	440	386	305	204	155
Bulk,	cc/g	2.85	2.61	2.44	2.35	1.63	2.80	2.79	2.48	2.35	1.65
Burst Factor		6	9	10	13	27	8	9	12	12	26
Tear Factor		27	32	38	41	66	28	32	38	40	61
Tensile, meters		2118	2341	2670	3263	5491	2397	2577	2935	3106	5520
Pulmac rejects (+0.006)	%		<0.01	0.01	<0.01	<0.01	0.01	0.01	0.01	<0.01	<0.01
BAUER McNETT FIBER CLASSIFICATION											
+ 14 mesh	%	-	<0.1	<0.1	<0.1	<0.1	-	0.2	<0.1	<0.1	<0.1
+ 28 mesh	%	-	2.1	1.1	1.1	0.7	-	4.2	3.4	2.0	1.1
+ 48 mesh	%	-	47.6	46.0	37.7	41.2	-	46.4	46.0	39.7	39.2
+100 mesh	%	-	27.9	27.4	30.5	29.4	-	28.5	29.1	28.6	30.5
+200 mesh	%	-	7.5	7.9	10.5	8.2	-	9.3	18.0	10.7	10.8
Total Retained + 200 mesh	%	-	85.1	82.4	79.8	79.5	-	88.6	88.5	81.0	81.6
Fines through 200 mesh	%	-	14.9	17.6	20.2	20.5	-	11.4	11.5	19.0	18.4
OPTICAL PROPERTIES											
Opacity, TAPPI, Elrepho	%	-	94.6	94.8	95.9	81.8	94.8	95.0	95.4	96.5	82.5
Brightness, TAPPI, Elrepho	%				53.2	77.3				51.6	74.2
Bleaching Yield,	%					94.8					94.7

ESB:83:32
March 1,1983

TABLE IV

SUMMARY OF UNBLEACHED AND BLEACHED PULP PROPERTIES

	BULK cc/g	BURST FACTOR	TEAR FACTOR	TENSILE km
AT 400 CSF				
Clear	2.6	12	46	3.2
Stained	2.7	8	31	2.2
Intermediate Decay	2.7	9	31	2.5
Advanced Decay	2.5	12	43	3.1
AT 300 CSF				
Clear	2.4	14	50	3.5
Stained	2.4	10	38	2.7
Intermediate Decay	2.5	11	38	2.9
Advanced Decay	2.5	13	44	3.3
AT 200 CSF				
Clear	2.4	16	50	3.9
Stained	2.4	14	41	3.3
Intermediate Decay	2.3	12	40	3.1
Advanced Decay	2.4	15	48	3.9
BLEACHED PULP AT 150 to 180 CSF				
Clear	1.7	28	65	5.7
Stained	1.6	27	66	5.4
Intermediate Decay	1.7	26	61	5.5
Advanced Decay	1.7	27	59	5.2

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TABLE V

SUMMARY OF PULP PROPERTIES

Wood Log Classification	Clear		Stained		Intermediate Decay		Advanced Decay	
Visual Rot, %	0		1.1		7.4		30.5	
Wood Brightness	65.5		53.8		57.2		49.6	
Pulp Bleached	No	Yes	No	Yes	No	Yes	No	Yes
Brightness	60.7	79.9	53.2	77.3	51.6	74.2	49.8	74.6
Opacity	94.7	81.5	95.9	81.8	96.5	82.5	96.4	83.6
CSF	213	151	203	154	204	155	197	184
Bulk, cc/g	2.4	1.7	2.4	1.6	2.4	1.7	2.4	1.7
Burst Factor	15	28	13	27	12	26	15	27
Tear Factor	50	65	41	66	40	61	48	59
Tensile, meters	3835	5694	3263	5491	3106	5520	3918	5229
Bauer McNett								
+14, %	-	-	-	-	-	-	-	-
+28, %	6.5	4.5	1.1	0.7	2.0	1.1	6.2	5.0
+48, %	41.1	39.2	37.7	41.2	39.7	39.2	41.1	44.9
+100, %	24.2	24.3	30.5	29.4	28.6	30.5	23.4	24.2
+200, %	10.2	12.7	10.5	8.2	10.7	10.8	8.1	8.0
-200, %	18.0	19.3	20.2	20.5	19.0	18.4	21.1	17.9

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TABLE VI

CALCULATED CHIP ROT CONTENT FOR DIFFERENT CHIP SCREENING

Chip Fraction	% Rot			
	Clear	Stained	Intermediate Decay	Advanced Decay
Unscreened	0	0.8	6.6	33.8
-7/8", +3/8"(used in this work)	0	1.1	7.4	30.5
-1 1/8", +3/8	0	0.9	6.4	27.8
-1 1/8", +3/16"	0	0.8	7.0	31.0

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TABLE VII

PROCESSING YIELDS

Wood Log Classification	Clear		Stained		Intermediate Decay		Advanced Decay	
Chipping Yield, %	99.4		99.3		99.5		99.5	
Chip Screening Yield								
a. -3/8", +3/16" rejected	No	Yes	No	Yes	No	Yes	No	Yes
b. Overs rechipping recovery, estimated %	90	89	90	88	88	85	85	75
Screened Chip Yield, % of o.d. wood	98.7	94.4	98	89.4	97.4	90.8	94.2	80.4
CTMP Yield, % of o.d. chips	94.6	94.6	94.6	94.6	94.7	94.7	89.4	89.4
Unbleached CTMP yield, % of o.d. wood	92.8	88.8	92.1	84.0	91.8	85.6	83.7	71.5
Bleached CTMP yield, % of o.d. chips	92.2	92.2	89.7	89.7	89.6	89.6	83.1	83.1
Bleached CTMP yield, % of o.d. wood	90.5	86.5	87.3	79.6	86.9	81.0	77.8	66.4

TABLE VIII

DATA FROM THE PREVIOUS PROJECT FOR ALBERTA FOREST SERVICE PEDOLOGY O'CHIESE STUDY

WOOD CLASS DESCRIPTION	1	2	3	4	5	6
	Sound, Bright, Aspen Round-Wood	Sound Bright, Aspen Slab-Wood	Stained Aspen	Aspen With Incip-ient Decay	Aspen With Advanc-ed Decay	Stained Balsam Poplar
Chemi-mechanical						
Refining passes	6	7	6	5	4	7
Bound Sulphur, %	0.14	0.07	0.11	0.13	0.24	0.15
Unbleached Brightness	61.6	65.7	50.6	46.4	39.7	52.2
Bleached Brightness	76.1	78.8	67.7	68.2	61.3	70.6
	unbl/bl	bl	bl	bl	bl	bl
Freeness	176/129	148	102	148	71	120
Burst Factor	24/ 31	31	30	33	29	24
Tear Factor	54/ 53	58	52	40	38	43
Tensile, km	5.0/6.2	5.9	5.3	5.9	5.8	5.2
Stretch, %	1.4/1.8	1.6	1.4	1.4	1.4	1.5
Porosity, sec/100ml	128/565	244	335	345	850	96
Opacity	93.1/77.8	85.5	83.3	83.1	86.7	84.8
Fibre Classification						
+48 mesh	48.7					
-100 mesh	25.6					

ESB:82:18

TABLE IX

DATA FROM THE PREVIOUS PROJECT FOR ALBERTA FOREST SERVICE PEDOLOGY O'CHIESE STUDY

WOOD CLASS DESCRIPTION	1	2	3	4	5	6
	Sound, Bright, Aspen Roundwood	Sound, Bright, Aspen Slab wood	Stained Aspen	Aspen With Incipient Decay	Aspen with Advanced Decay	Stained Balsam Poplar
CHIPS						
VISUAL						
Sound, %	100	100	34	12	8	41
Stained, %			55	53	31	54
Incip. decay, %			8	25	16	5
Adv. decay, %			3	10	45	--
Wood brightness, %	69.9	71.9	54.2	47.6	31.7	51.0
Bulk density, lb/ft^3	8.0	8.6	8.5	8.2	6.6	8.3
Chip fines(-3/8"), %	2.9	2.6	6.5	16	16	4.6
KRAFT PULP						
Total yield, %	55.1	56.7	56.2	51.8	45.8	54.7
Bleached pulp viscosity	32.0	31.4	28.3	26.6	20.3	30.6
Bleached pulp freeness	512	581	420	340	191	482
Strength @ 300 freeness					191CSF	
Beating req., revs	2300	3200	1800	400	---	2250
Burst factor	65	66	56	48	44	67
Tear factor	82	91	77	71	66	95
Tensile, km	10.2	10.2	9.0	8.0	7.7	10.3
THERMOMECHANICAL PULP						
Brightness	66.7	71.5	54.5	49.4	33.2	51.1
Burst factor	12	12	9	8	10	10
Tear factor	30	37	19	17	22	25
Tensile, km	2.4	2.7	2.2	1.8	2.3	2.4
BLEACHED CHEMIMECHANICAL PULP						
Brightness	76.1	78.8	67.7	68.2	61.3	70.6
Burst factor	31	31	30	33	29	24
Tear factor	53	58	52	40	38	43
Tensile, km	6.2	5.9	5.3	5.9	5.8	5.2

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TABLE X

DATA FROM PREVIOUS PROJECT FOR ALBERTA FOREST SERVICE
PEDOLOGY O'CHIESE STUDY

Specified Defect Limit for Logs to the Pulp Mill		Log Volume for Average Defect Content		Kraft Pulp		Thermomechanical Pulp		Bleached Chemimechanical Pulp	
Stain %	Decay %	% of Aspen Volume	AAC 000M3	Decrease in Pulp Drainage %	Decrease in Pulp Strength %	Pulp Brightness	Decrease in Pulp Strength %	Pulp Brightness	Decrease in Pulp Strength %
0	0	11.6	53	0	0	67	0	76	0
5	0	30	140	1.5	0.8	66	2	75.5	0.2
10	0	39.5	180	3	1.5	65	4	74.7	0.4
15	0	46	210	4.5	2.3	64	6	74	0.6
19	0	49.9	226	5.7	2.9	63.8	8	73.5	0.8
100	0	-	-	30	15	50	42	63	4
0	0			0	0	67	0	76	0
0	2.6			1.5	0.8	66.3	1.3	75.6	0.4
0	5.0			3	1.5	65.6	2.5	75.2	0.7
0	8.7			5.2	2.6	64.7	4.4	74.6	1.3
0	100			60	30	40	50	60	15
19	8.7	100	458	10.9	5.5	61.3	12.4	72.1	2.1

NOTE: The decrease in pulp properties for wood with decay and stain will be the sum of the decrease for each defect (eg., 10 % stain plus 5 % decay will lower TMP strength 6.5 %).

TABLE XI

EFFECTS OF STAIN AND DECAY ON MILL COSTS AND PRODUCTION RATE

WOOD LOG CLASSIFICATION	CLEAR	STAINED	INTERMEDIATE DECAY	ADVANCED DECAY	An Example 70% Clear 20% Stain or Int. 10% Adv. Decay
Chip Screening Yield, % (retaining -3/8,+3/16 fraction)	98.7	98.0	97.4	94.2	
CTMP Yield, % of Chips	94.6	94.6	94.7	89.4	
Bleaching Yield, % of pulp	97.5	94.8	94.7	92.9	
Overall Bleached CTMP Yield, % on O.D. Wood	90.5	87.3	86.9	77.8	
Wood Usage, Kg/BADMT(900 Kg)	994	1031	1036	1157	1018
Estimated Cooking Chemical Usage					
Na_2SO_3, % on O.D. Chips	9	9	9	10	
Kg per BADMT	88	90	90	108	90.4
Estimated Bleaching Chemical Usage, H_2O_2, % on O.D. Pulp	2.2	3.0	3.1	3.3	2.5
Production Capacity					
% of Clear Wood Capacity					
Chipping	100	96	96	86	97.8
Chip Screening	100	96	96	86	97.8
Cooking and Refining	100	97	97	90	98.4
Bleaching	100	97	97	95	98.9
Drying	100	100	100	100	100

BADMT = Bleached Air Dried (90%) Metric Tonne

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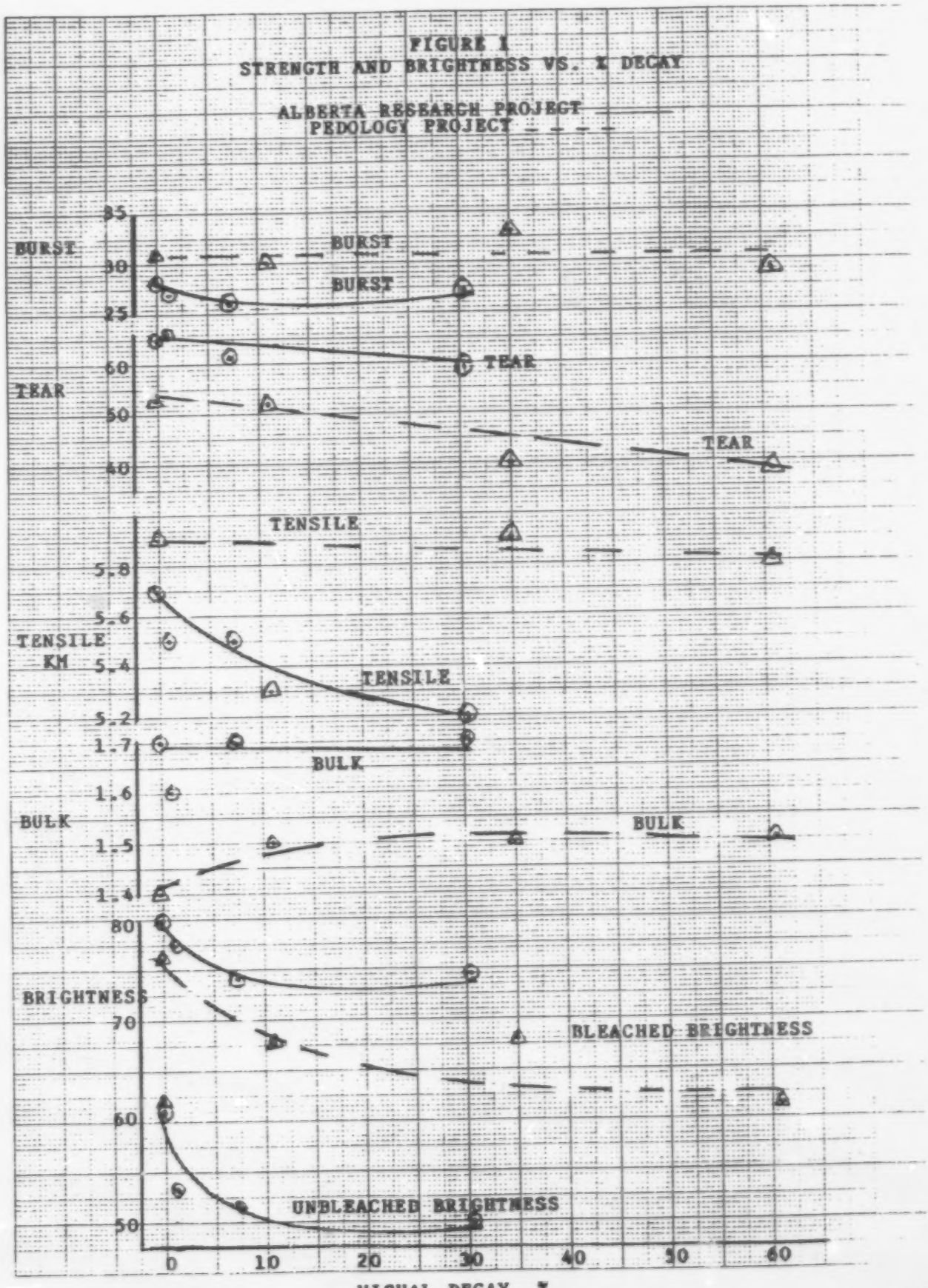
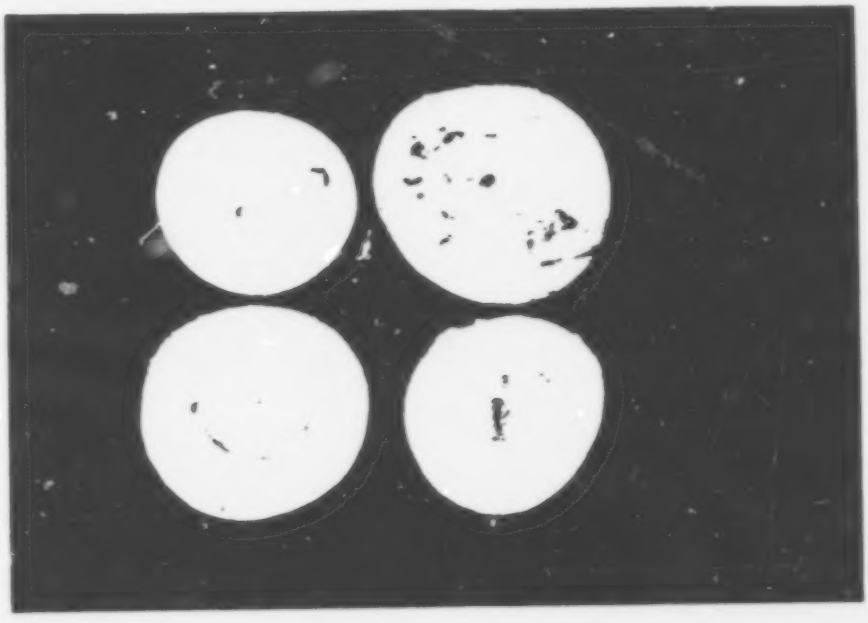
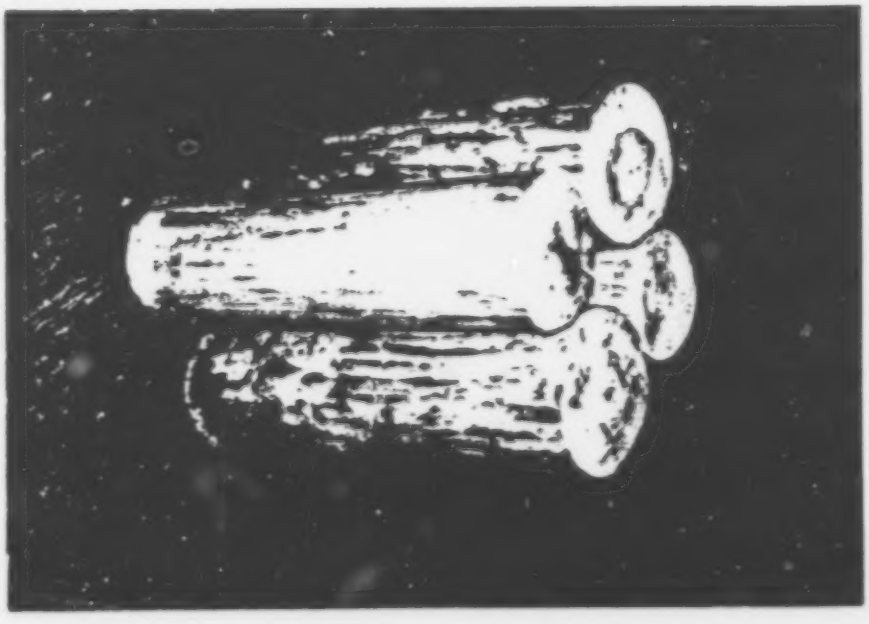


FIGURE 1
STRENGTH AND BRIGHTNESS VS. % DECAY
ALBERTA RESEARCH PROJECT
PEDOLOGY PROJECT
BURST
TEAR
TENSILE
KM
BULK
BRIGHTNESS
BLEACHED BRIGHTNESS
UNBLEACHED BRIGHTNESS
VISUAL DECAY, %

ALBERTA RESEARCH COUNCIL



CLEAR LOGS



CLEAR LOGS

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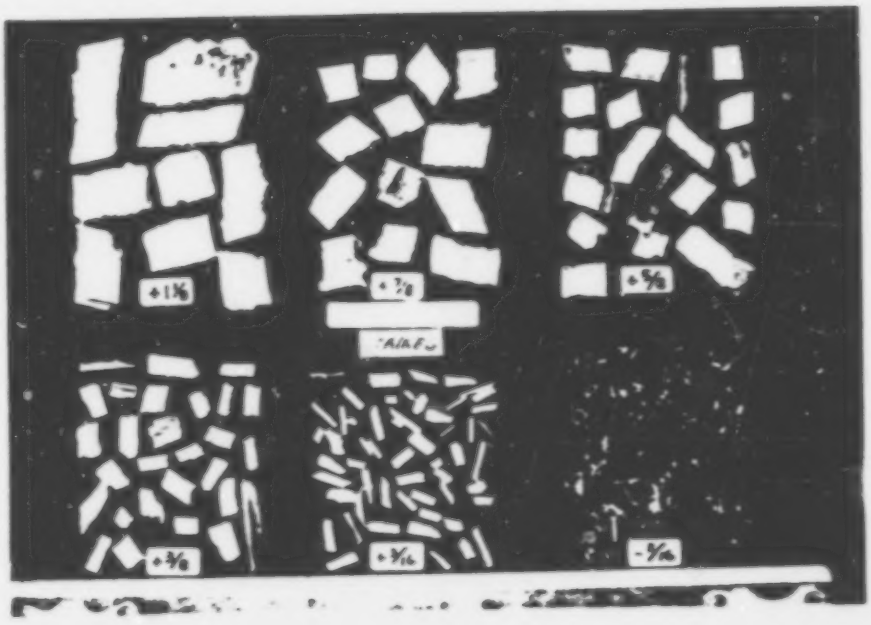

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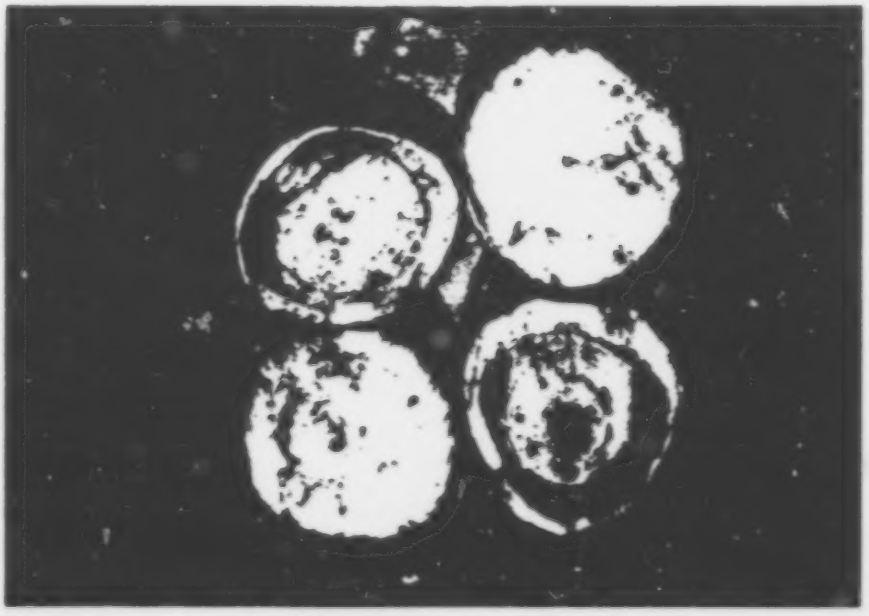
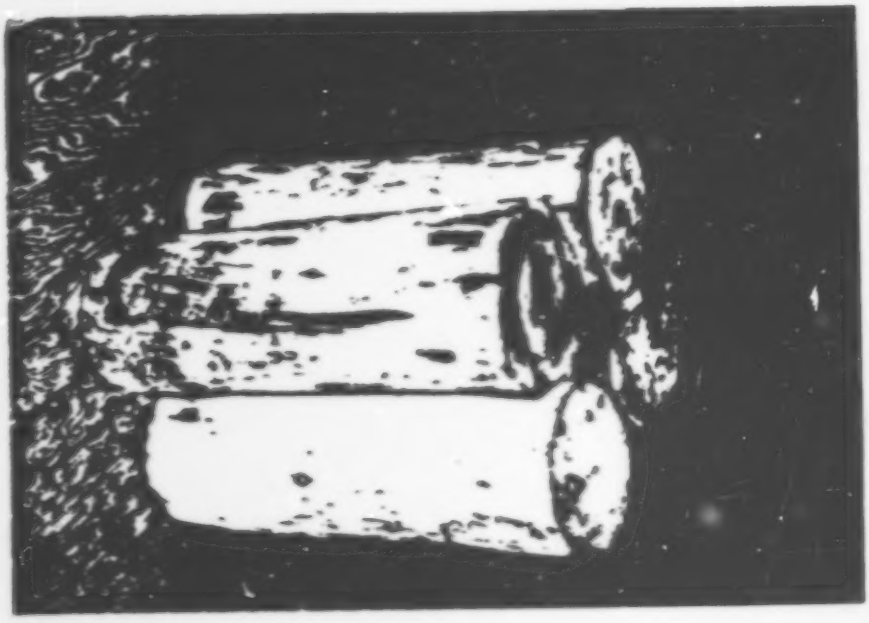
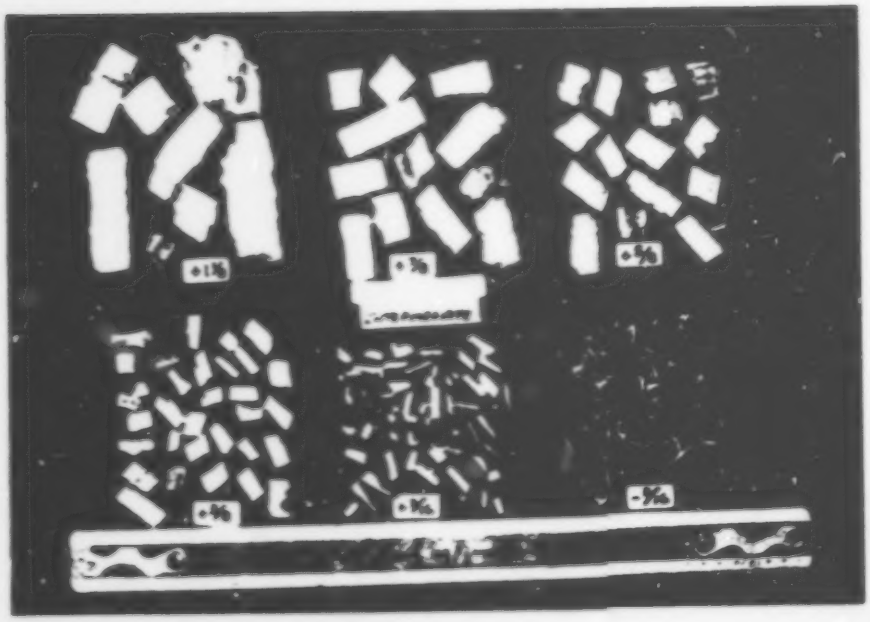


STAINED LOGS

ECONOTECH



STAINED LOGS



INTERMEDIATE DECAY CHIPS

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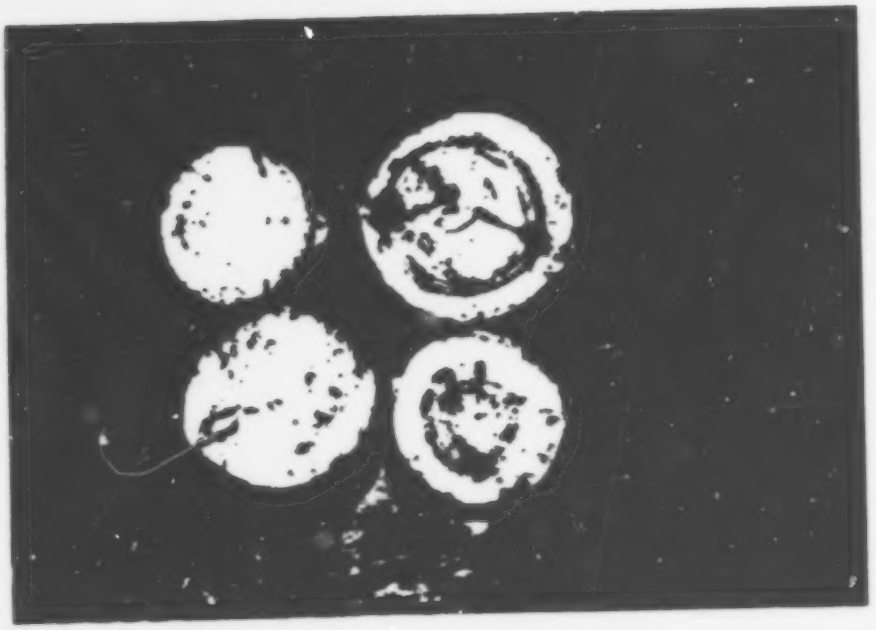

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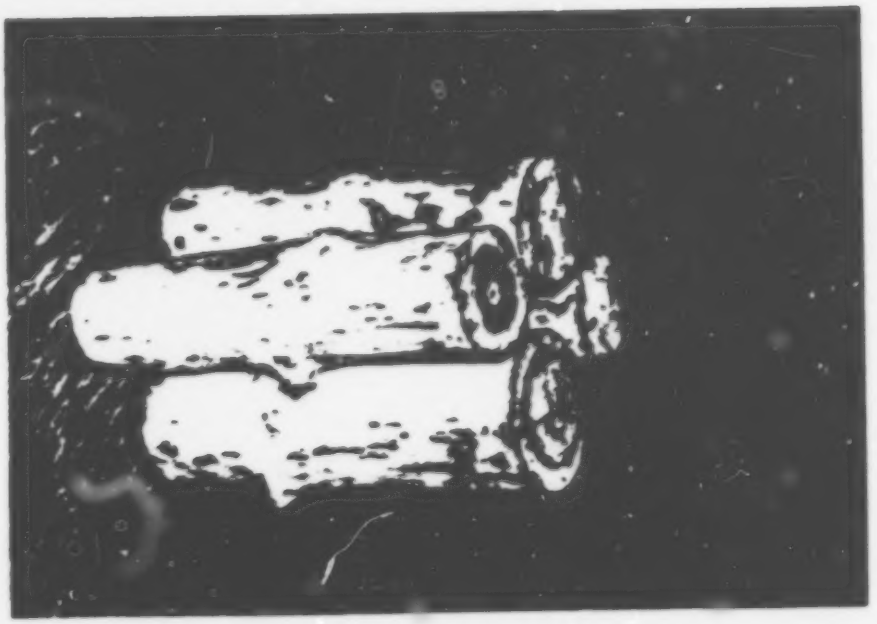

INTERMEDIATE DECAY LOGS

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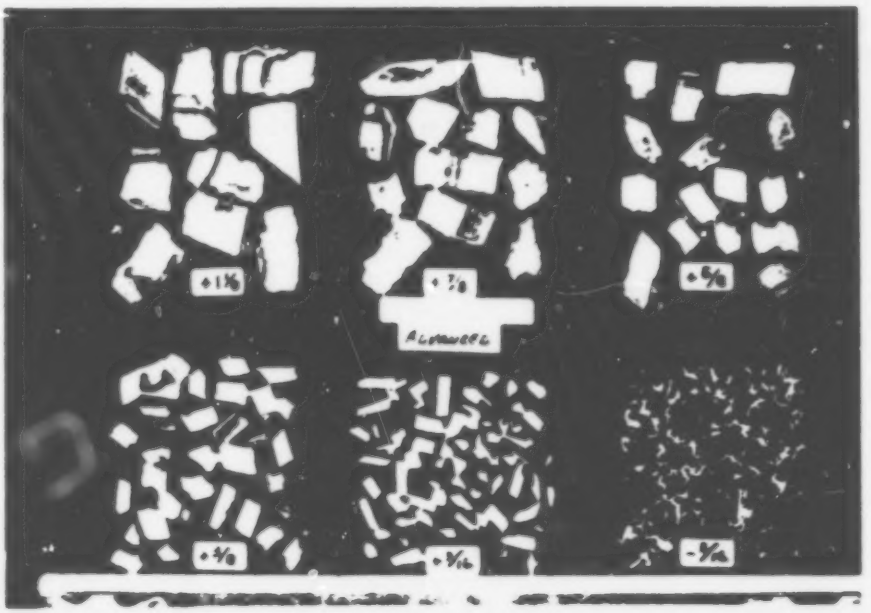
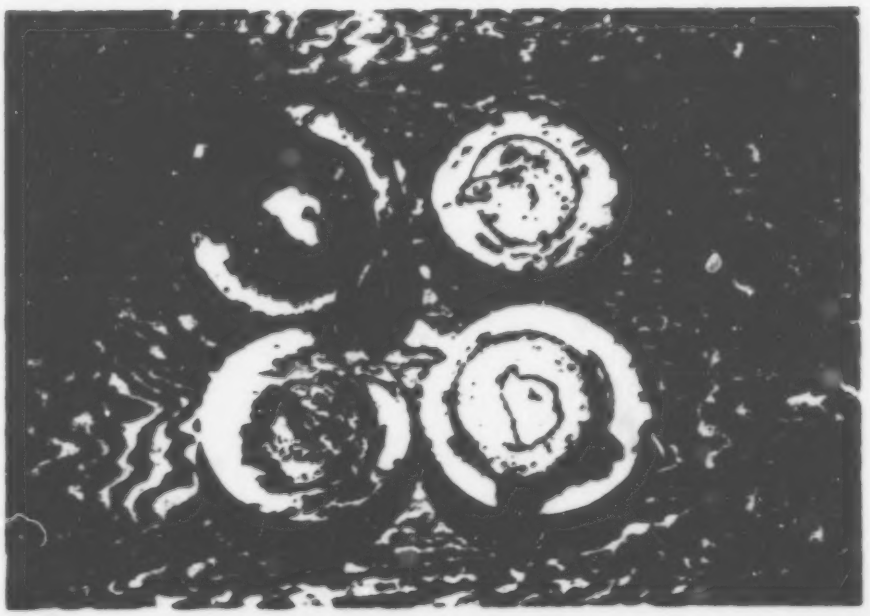


ADVANCED DECAY CHIPS



ADVANCED DECAY LOGS

ECONOTECH

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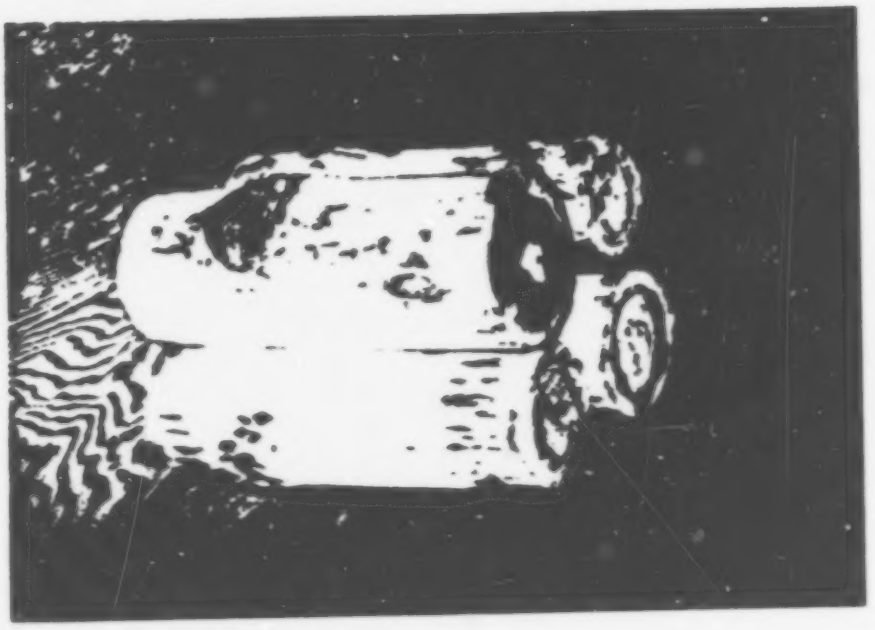

ADVANCED DECAY LOGS

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CLEAR BLEACHED

CLEAR UNBLEACHED

ECONOTECH

ALBERTA RESEARCH COUNCIL

STAINED BLEACHED

STAINED UNBLEACHED

ECONOTECH

ALBERTA RESEARCH COUNCIL

INTERMEDIATE DECAY BLEACHED

INTERMEDIATE DECAY UNBLEACHED

ECONOTECH

ALBERTA RESEARCH COUNCIL

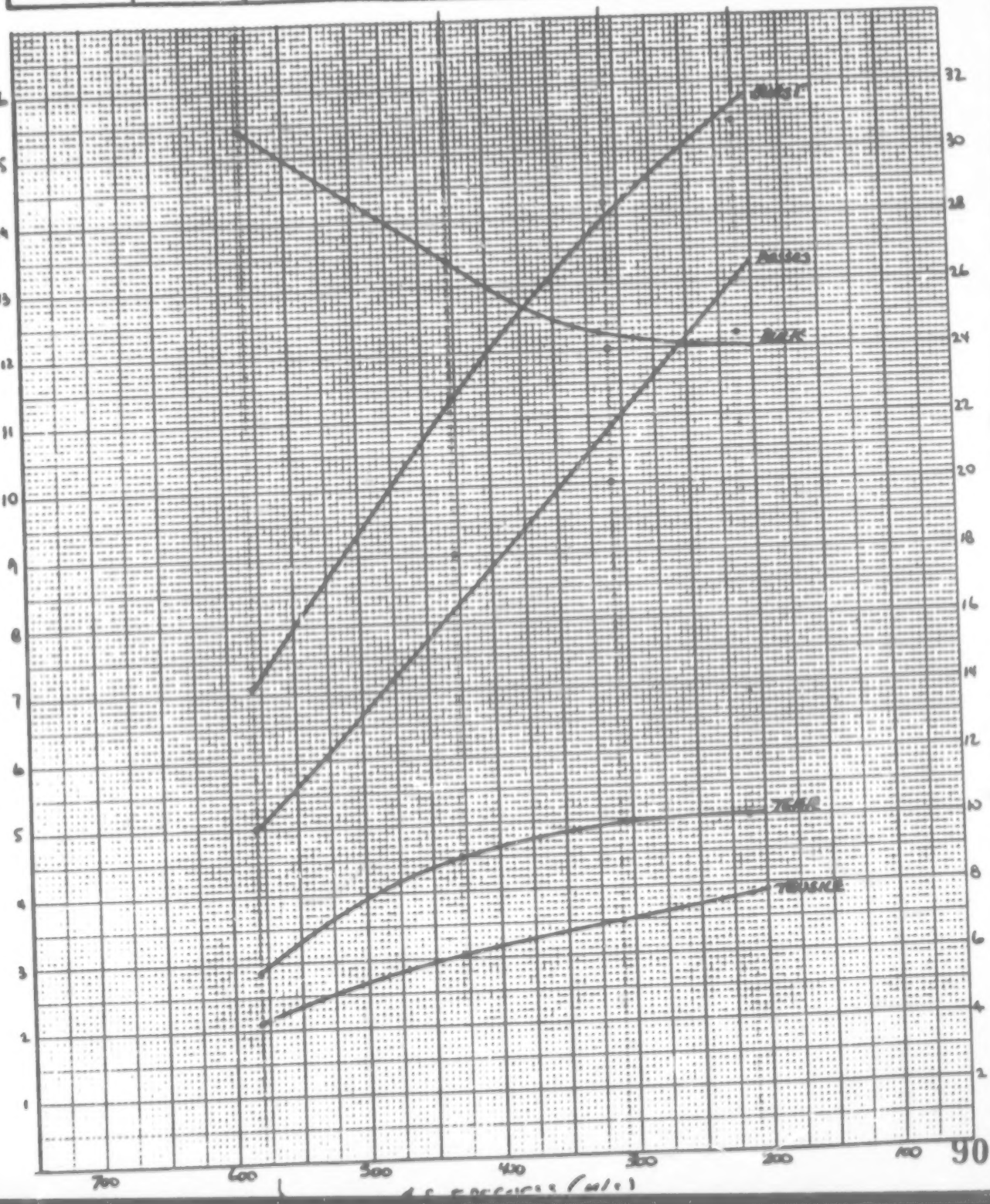
ADVANCED DECAY BLEACHED

ADVANCED DECAY UNBLEACHED

ECONOTECH

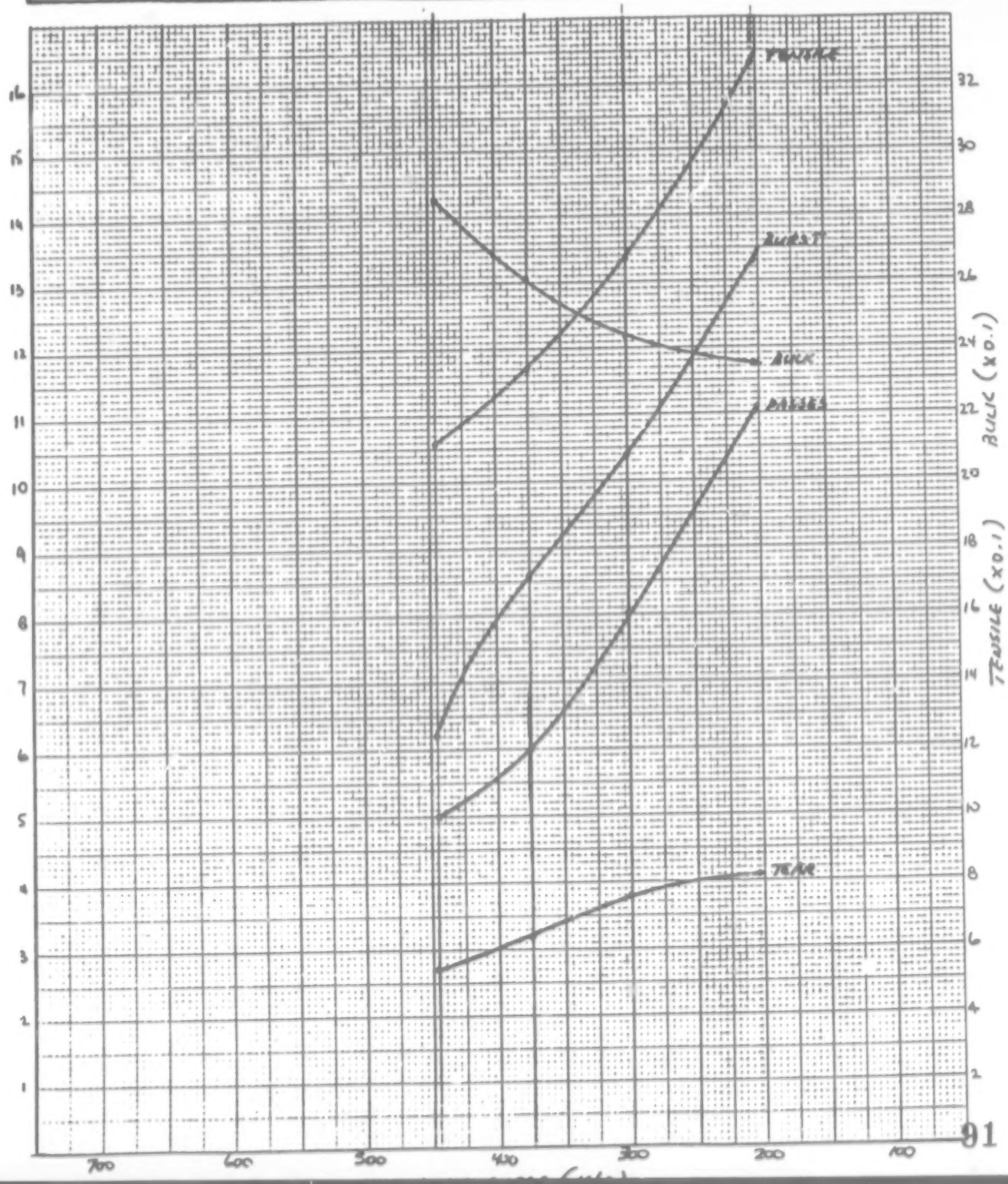
ASPEN-CLEAR (-7/6 + 3/6) 08/FEB/83 - SAA

C.S.F. mls	PASSES	Burst Factor	Tear Factor	Tensile km	Bulk cm^3/gm	Opacity %	PAPCHAC
400	8.8	12.0	46.4	3.16	2.60		
300	11.0	14.2	49.5	3.52	2.44		
200	8.3	15.8	50.2	3.90	2.40		



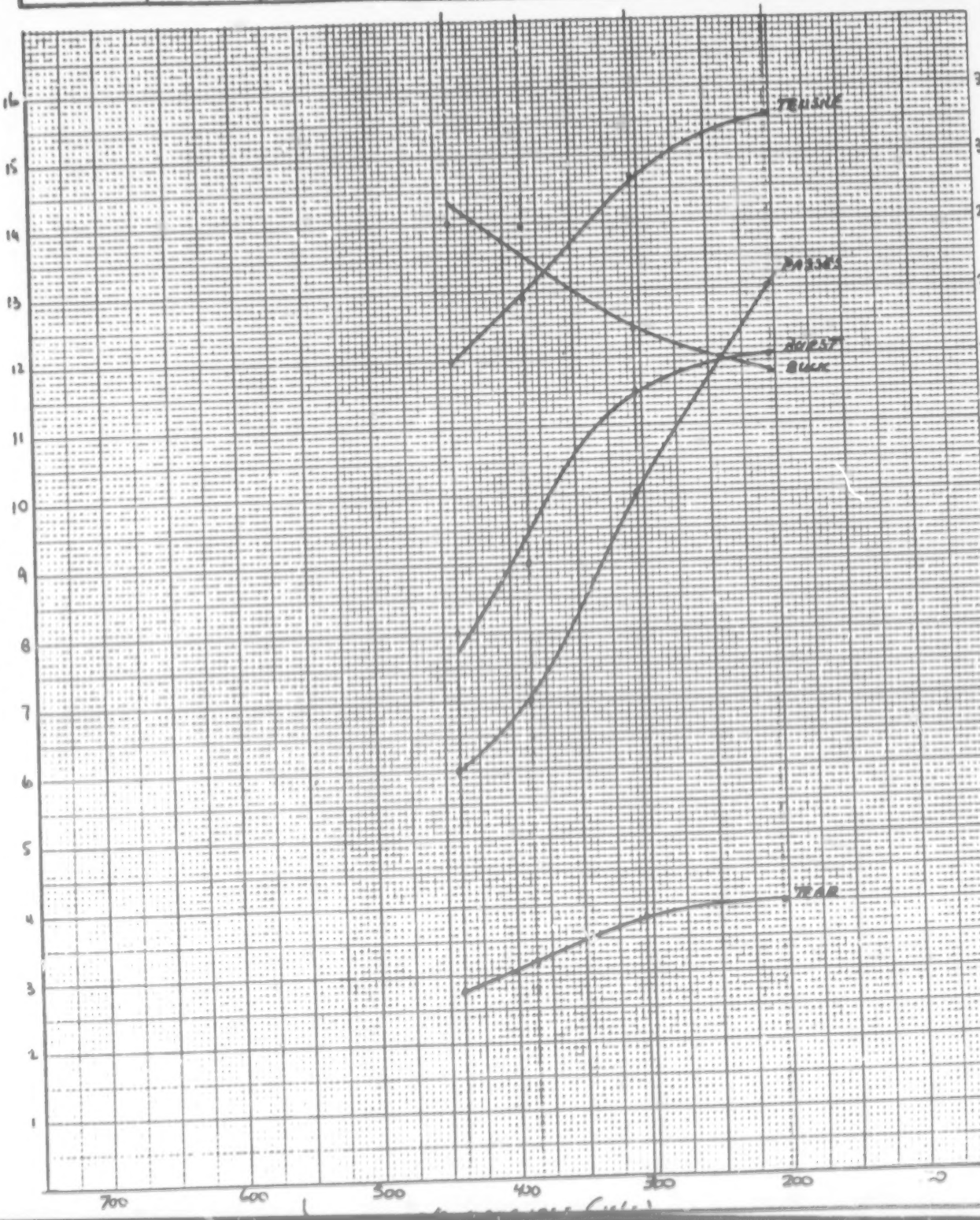
ASPEN - STANNED (-7/8 +3/8) 14/FEB/83 RP/SEH

C.S.F. mls	PASSES	Burst Factor	Tear Factor	Tensile km	Bulk cm^3/gm	Opacity %	PULMAC
400	5.6	7.9	30.5	225	2.68		
300	8.0	10.4	38.0	268	2.44		
200	11.1	13.5	41.0	3.29	2.35		



ASPEN . INTERMEDIATE (-⅞+⅜) 14/FEB/83 RP/SKA

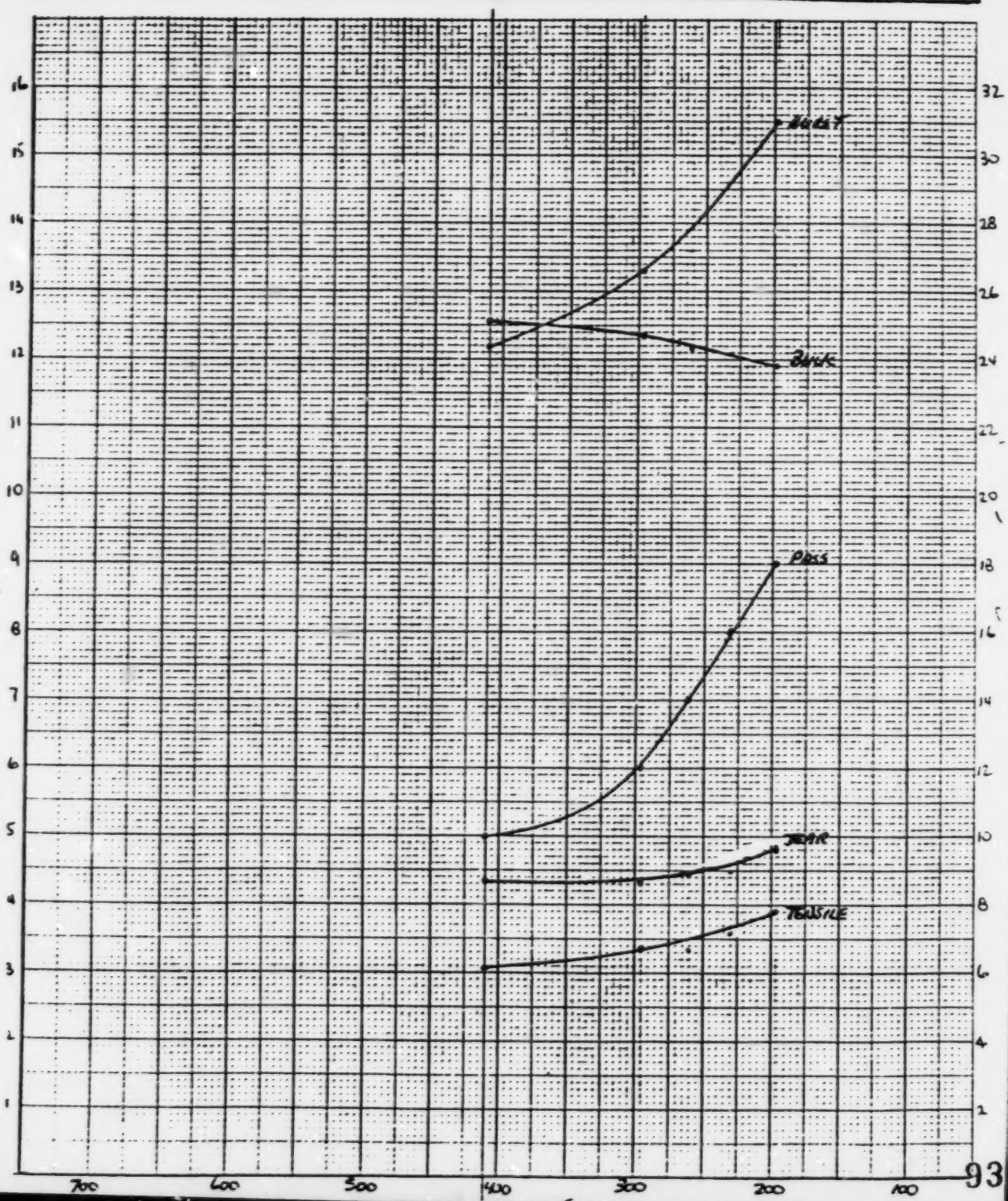
C.S.F. mls	PASSES	Burst Factor	Tear Factor	Tensile km	Bulk cm^3/gm	Opacity %	PULMAC
400	6.7	9.0	31.0	2.54	2.74		
300	10.2	11.5	38.9	2.93	2.48		
200	13.2	12.0	40.0	3.11	2.34		



K·E 10 X 10 TO ½ INCH 2 X 10 INCHES KEUFFEL & ESSER CO MADE IN U.S.A.
46 1320

ASPEN : ADVANCED KOT (-7/8+3/8) 09/FEB/83 SRN

C.S.F. mls	PASSES	Burst Factor	Tear Factor	Tensile km	Bulk cm^3/gm	Opacity %	PULMAC
400	5.0	12.2	43.2	3.10	2.51		
300	6.0	13.3	43.8	3.32	2.47		
200	8.9	15.4	48.0	3.86	2.38		



K·E 10 X 10 TO ½ INCH 7 X 10 INCHES
KEUFFEL & ESSER CO MADE IN U.S.A.
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PASS TEAR (KN) BURST TENSILE

Chapter 11

LABORATORY PRINTING STUDIES

MacMillan
Bloedel Research

MacMILLAN BLOEDEL RESEARCH

Pulp and Paper Division

TECHNICAL SERVICE REPORT

Project P-4056

EVALUATION OF THE STANDARD PHYSICAL PROPERTIES AND PRINTING CHARACTERISTICS OF ASPEN-CTMP PULPS IN MIXTURES WITH 25% SEMIBLEACHED KRAFT

March 9, 1983

Prepared by:

R.G. Meret and L. Szanyi

Approved by:

A.R. Procter

REPORT

EVALUATION OF THE STANDARD PHYSICAL PROPERTIES AND PRINTING CHARACTERISTICS OF ASPEN-CTMP PULPS IN MIXTURES WITH 25% SEMIBLEACHED KRAFT

by

L. Szanyi and R.G. Meret

PROCEDURE

As in previous evaluations, standard TAPPI handsheets were used for the evaluation of the basic properties of the pulps, while MK 12" x 12" sheets were used for the printing and GFL surface strength tests.

The MK sheets were pressed air dry between smooth stainless steel plates under 800 psi pressure to simulate calendering. Two compression times, 2 hours and 24 hours, were used to obtain two distinct sheet density levels.

The printing conditions are described in Appendix I, which was taken from the previous report.

RESULTS

The standard tests made on TAPPI handsheets are reported in Table I. These results require no comment.

The physical and printing tests made on the MK handsheets are reported in Table II. In this case it was found, as in previous occasions, that the scattering coefficients were some 15% higher than for the corresponding TAPPI handsheets. The main reason for the difference appears to be mainly related to a difference in structure due in turn to the manner in which the stock is agitated before draining the water.

In the case of the MK sheets a stream of air is injected in the stock which is thus momentarily mixed with fine air bubbles, which, we believe, tend to affect the microformation of the sheet and degree of bonding between fibers. Another probable contributing factor is the high pressure used on the air dry sheets, possibly at 6% to 7% moisture, in order to simulate calendering, with the MK sheets compared to the wet pressing under very moderate pressure, 50 psi, used for the standard TAPPI sheets. It is believed that in the case of the

MK sheets the high calendering pressure results in the breaking of some fiber-to-fiber bonds and thus in an increase in unbonded specific surface and in scattering coefficient. Evidence of this affect was provided in the case of the GFL surface strength tests (Figure 3).

The data in Table II also indicated a substantial degree of two-sidedness particularly in GFL surface strength.

An overall comparison of basic and printing properties between the CTMP samples from "clear" and "advanced" chips is shown in Table III. The properties of the sheets from "clear" chips were perceptibly better.

The degree of caliper relaxation of the handsheets after static calendering is indicated in Table IV.

The interpolation of ink demand and print-through at a given sheet density can be made, respectively, from Figure 1 and Figure 2.

The static calendering of the air dry sheets with a probable moisture content of between 6% and 7%, as in other occasions, had a negative influence on surface strength (Figure 3). This effect can be controlled in practice by calendering at a higher moisture content, by pressing of the still wet sheets under higher load and, whenever possible, by refining the pulps to a higher degree before paper making.

LS/RGM/vp
March 9, 1983

TABLE I

STANDARD TAPPI HANDSHEET PROPERTIES OF TWO ASPEN CTMP PULP MIXTURES WITH 25% SB KRAFT

1 = 75% CTMP from chips with advanced decay

2 = 75% CTMP from clear chips

Woodbridge & Reed Pulp Samples 04-Mar-83

Sample	75% Adv +25% K	75% Clear +25% K
Cs Freeness, ml	369	351
Drainage Time, sec	5.0	5.3
Basis Weight, gm/m^2	59.8	59.2
Caliper, microns	105	103
Density, gm/cm^3	0.567	0.574
Tear Index, $mN.m^2/gm$	9.4	10.0
Burst Index, $kPa.m^2/g$	2.60	2.52
Breaking Length, meters	5940	6040
Stretch, %	1.8	1.8
TEA Index, mJ/g	721	710
Brightness, %	67.3	69.7
Opacity, %	75.3	74.8
Scattering Coeff., cm^2/gm	328	332
Absorption Coeff., cm^2/gm	10	9

TABLE II

PHYSICAL PROPERTIES AND PRINTABILITY TESTS MADE ON HANDSHEETS PREPARED ON M/K SHEET FORMER FROM TWO MIXTURES OF ASPEN CTMP PULPS WITH SB KRAFT

Static Calendering Time, Hours	2		24	
Pulp Mixture: 75% Aspen CTMP 25% Kraft	"Clear"	"Advanced"	"Clear"	"Advanced"
SHEET PROPERTIES				
Basis Weight, g/m^2	70.1	70.0	70.1	70.0
Sheet Density, g/cm^3	.686	.671	.704	.700
Sheffield Roughness, ml/min T/W	142/135	151/143	109/102	118/114
Sheffield Porosity, ml/min	103	100	98	106
Formation, Lin-C	26.5	33	26	32
Brightness, %	69.7/69.3	67.7/67.3	69.7/68.9	68.0/67.0
Opacity, %	84.7	84.8	85.0	84.8
Scattering Coefficient, cm^2/g	384	366	385	368
GFL Surface Strength Kdynes/cm T/W	10.7/14.6	10.7/14.6	9.1/11.7	9.2/11.2
PRINTING PROPERTIES				
Ink Demand, g/m^2 at Print Density = 1.0 T/W	2.80/2.65	2.95/2.85	2.75/2.65	2.85/2.80
Print-Through at Print Density = 1.0 T/W	.140/.139	.146/.145	.152/.151	.160/.150

TABLE III

PRINTING AND BASIC PROPERTIES OF HANDSHEETS OF ASPEN CTMP PULPS
(Data - Top and Wire Side Average - Interpolated at 0.70 g/cm³ Sheet Density)

Pulps	"Clear" "A"	"Advanced" "B"	Difference %
1. PRINTING PROPERTIES at 0.70 g/cm sheet density			"A"/"B"
Ink Demand, g/m² at print density = 1.0	2.72	2.81	-3
Print-through at print density = 1.0	.148	.155	-5
2. BASIC PROPERTIES			
Sheffield Roughness, ml/min	106	116	-8
Sheffield Porosity, ml/min	99	106	-7
Scattering Coefficient, cm²/g	386	368	+5
GFL Surface Strength, Kdynes/cm	10.5	10.2	+3

*Printing conditions are given in Appendix I

TABLE IV

RELAXATION OF HANDSHEETS AFTER STATIC CALENDERING FOR 2 AND 24 HOURS AT 800 PSI

PULP	"CLEAR"	"ADVANCED"
MIXED STOCK FREENESS, ml	351	369
1. Sheets as Made		
Basis Weight, g/m^2	70.1	70.0
Caliper, µm	129	134
Density, g/cm^3	.543	.522
2. Sheets Pressed 2 Hrs Between Smooth Stainless Steel Plates Under 800 psi		
a. Immediately after pressing		
Caliper, µm	99	101
Density, g/cm^3	.708	.693
b. Stored and allowed to expand in print lab in plastic bag overnight		
Caliper, µm	102	104
Density, g/cm^3	.687	.673
3. Sheets Pressed 24 Hrs Between Smooth Stainless Steel Plates Under 800 psi		
a. Immediately after pressing		
Caliper, µm	95	96
Density, g/cm^3	.738	.729
b. Stored and allowed to expand in print lab in plastic bag overnight		
Caliper, µm	99.5	100
Density, g/cm^3	.704	.700

APPENDIX I of the Nov 20, 81 report

PRINTABILITY TEST OF CM PULP HANDSHEETS
FROM WOODBRIDGE AND REED

1. PRINTING CONDITIONS

Press	:	PRUFBAU - Multipurpose printability tester
Ink	:	Regular letterpress ink with 12% carbon black pigment
Printing Impression	:	400N = 10 kg/cm
Printing Speed	:	3 m/sec
Prints Made	:	Four prints on each side of the sheet at two sheet density levels
Print Size	:	4 x 20 cm = 80 cm^2/print

2. TESTS MADE ON PRINTS

Print Density : $\text{Log}_{10} \frac{\text{Reflectance on paper}}{\text{Reflectance on print}}$

Print-through : $\text{Log}_{10} \frac{\text{Reflectance of paper on opposite side of the print}}{\text{Reflectance of print shadow}}$

FIG 1

INK DEMAND VS. SHEET DENSITY AT PRINT DENSITY = 1·0

LEGEND: EACH POINT IS THE AVERAGE FOR BOTH SIDES OF THE SHEET
– IN THE CIRCLES ARE THE ROUGHNESS VALUES.

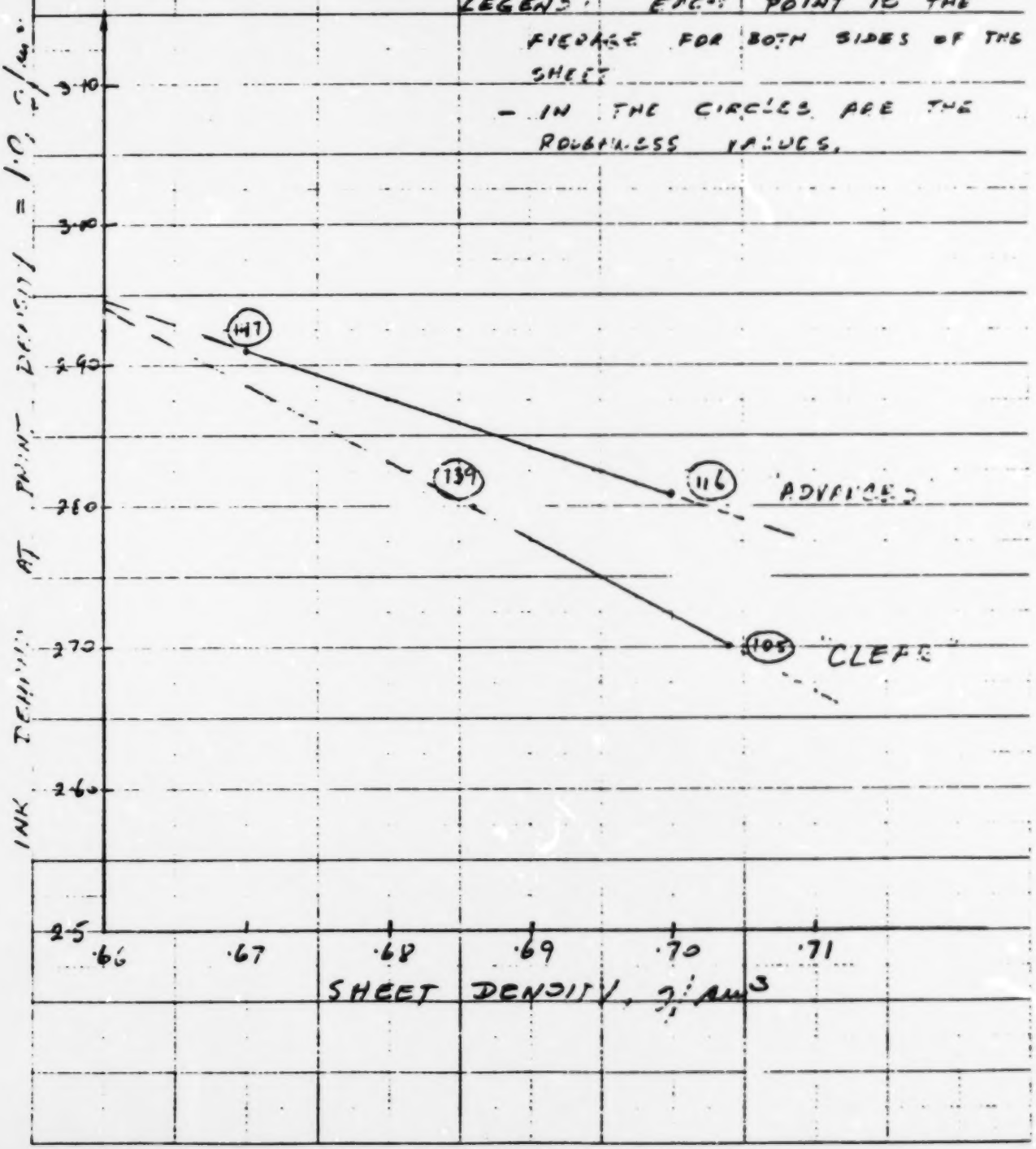


FIG 2

PRINT THROUGH VS. SHEET DENSITY
AT PRINT DENSITY = 1.0

LEGEND: EACH POINT IS THE AVERAGE FOR BOTH SIDES OF THE SHEET
– IN CIRCLES ARE THE SCATTERING COEFFICIENT VALUES

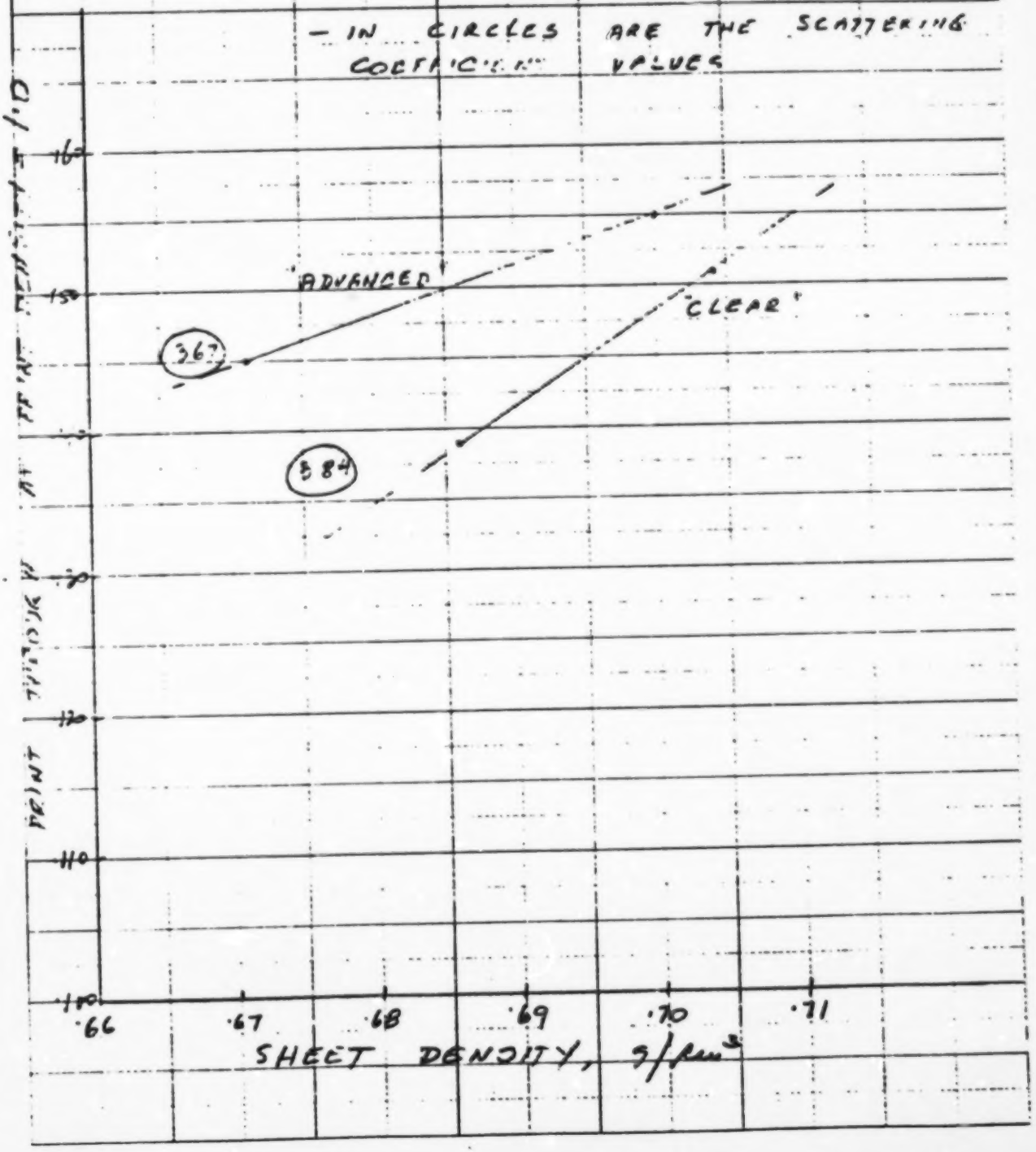
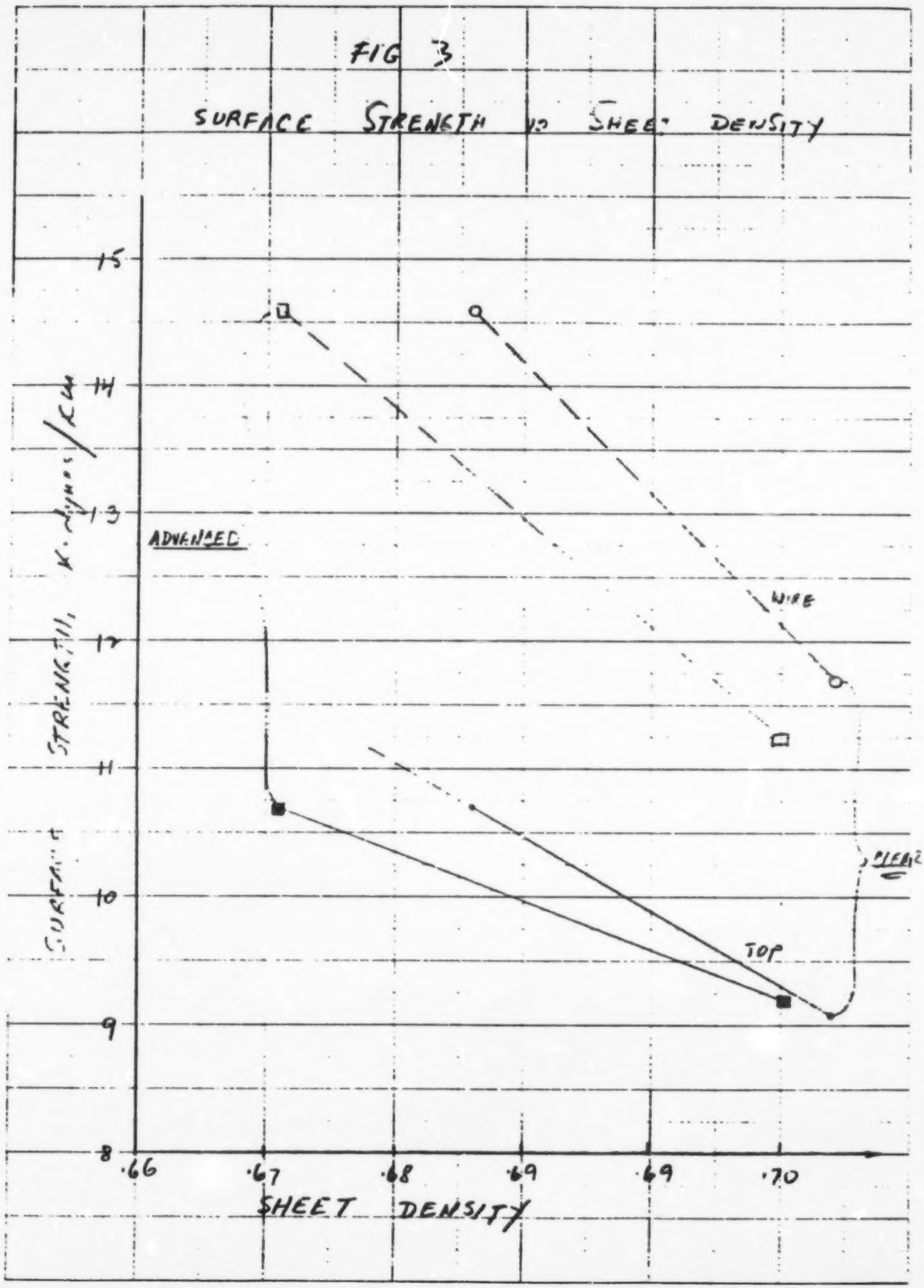


FIG 3

SURFACE STRENGTH V.S SHEET DENSITY



POOR

QUALITY

ORIGINAL